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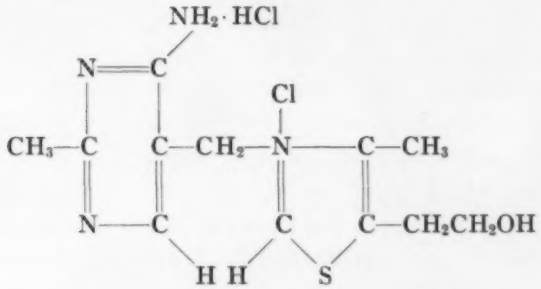
Thiamin and growth of species of Phytophthora[1]

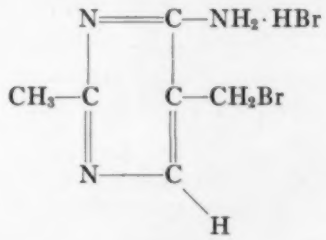
WILLIAM J. ROBBINS
(WITH TWO FIGURES)

Since the demonstration of the necessity of thiamin (vitamin B_1) for the growth of *Phycomyces Blakesleeanus* by Schopfer (11) the relation of this vitamin and its pyrimidine and thiazole intermediates to the growth of a number of fungi has been reported. Thiamin hydrochloride has the following structure:

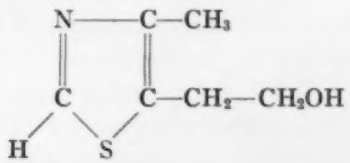


It was synthesized by Williams and Cline (15) from a pyrimidine and a thiazole of the following composition:

2-methyl-5-bromomethyl-6-aminopyrimidine hydrobromide



4-methyl-5 β hydroxyethylthiazole



[1] The author gratefully acknowledges the assistance of Frederick Kavanagh and Frederick C. Robbins.

[THE BULLETIN FOR APRIL (65: 211–265) WAS ISSUED APRIL 1, 1938]

It was found that *Phycomyces Blakesleeanus* grows satisfactorily in a medium containing the two intermediates instead of the vitamin (7, 12, 13) and that the growth of *Phycomyces* is not, therefore, conclusive evidence of the presence of thiamin. In fact, it appears that *Phycomyces* actually requires thiamin and though capable of forming it from the two intermediates, it is unable to synthesize either intermediate from the mineral salts, sugar and asparagine which constitute the basic medium (7). Other fungi which grow poorly or not at all on a medium of mineral salts, sugar and asparagine are able to synthesize the vitamin thiazole but little or none of the intermediate pyrimidine (8). These organisms require for growth an external supply of the pyrimidine. Still others synthesize pyrimidine but little or no thiazole and require the latter compound (6). None of these organisms can be said to require an external supply of thiamin since they grow satisfactorily if furnished with one or both of the intermediates.

Are there fungi which require an external supply of thiamin and are incapable of using the intermediates? From our investigations we have concluded that several species of *Phytophthora*, probably most of this genus belong to such a group (9).

METHODS AND MATERIALS

The following species of *Phytophthora* kindly furnished by C. M. Tucker were used:
Phytophthora Boehmeriae Saw., *P. cactorum* (L. and C.) Schwet., *P. cambivora* (Petri) Buis., *P. capsici* Leon., *P. cinnamomi* Rands, *P. citrophthora* (Sm. and Sim.) Leon., *P. cryptogea* Pethyb. and Loff., *P. Dreschsleri* Tuck., *P. fagopyri* Takemoto, *P. palmivora* Butler, and *P. parasitica.* Dast.

The fungi were grown in 25 ml. of liquid medium in 150 ml. Erlenmeyer flasks of pyrex glass at room temperature (18–24° C). The media were sterilized at 110° C for 20 minutes unless otherwise noted. The stock cultures were grown on oatmeal agar or potato dextrose agar. A bit of mycelium, a millimeter or two in diameter was used as inoculum, care being taken to avoid including any of the agar of the stock cultures with the inoculum. The commercial asparagine was purified for some experiments by repeated solution in water and precipitation with alcohol. The thiamin was Merck's synthetic betabion; the thiazole was 4-methyl-5-hydroxyethylthiazole and the pyrimidine, 2-methyl-5-bromomethyl-6-aminopyrimidine hydrobromide. Both the latter compounds were generously supplied by Merck and Co. through the courtesy of R. R. Williams.

The amount of thiamin or its intermediates added per flask is expressed in units. One unit is 10^{-9} Mole. All cultures were grown in triplicate.

Two basic media were employed: solution C, consisting of 0.5% $MgSO_4 \cdot 7H_2O$, 1.5% KH_2PO_4, 0.05% NH_4NO_3, 1.5% asparagine and 5% dextrose; solution D which contained per liter 1 g KNO_3, 1 g NH_4NO_3, 0.5 g KH_2PO_4, 0.25 g $MgSO_4 \cdot 7H_2O$, 25 g dextrose and Steinberg's mineral supplements (14) as follows: 0.02 ppm. Mo, 0.05 ppm. Fe, 0.04 ppm. Cu, 0.18 ppm. Zn and 0.02 ppm. Mn.

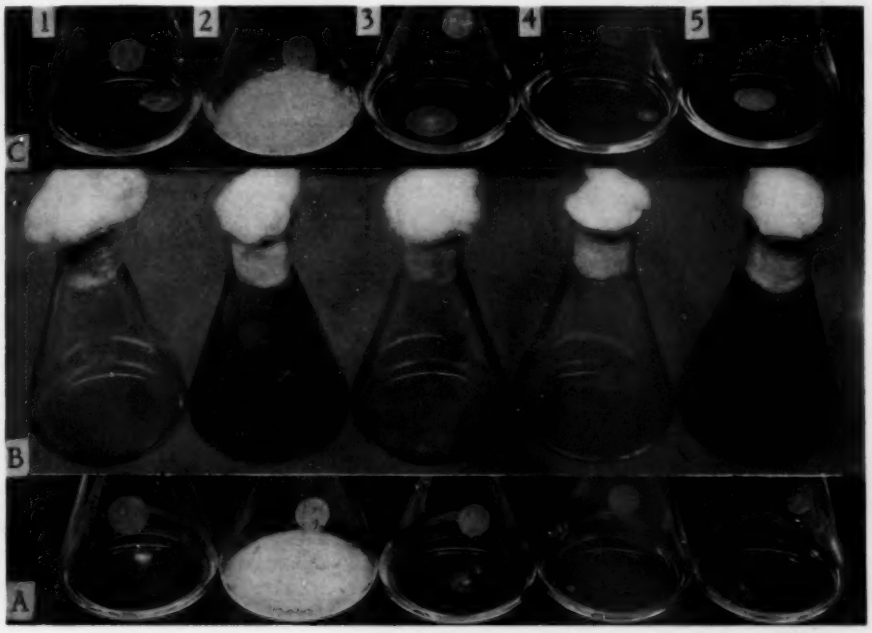


Fig. 1. Fungi grown in, (1) solution C and the same solution plus, (2) 30 units thiamin, (3) 30 units thiazole, (4) 30 units bromo-pyrimidine; (5) 30 units thiazole and 30 units bromo-pyrimidine. A = *Phytophthora cinnamomi*, B = *Phycomyces Blakesleeanus*, C = *Phytophthora Boehmeriae*.

EXPERIMENTAL

When these species of *Phytophthora* were grown in (1) solution C, in solution C supplemented with (2) 30 units of thiamin, (3) 30 units of thiazole, (4) 30 units of pyrimidine or (5) a mixture of 30 units of each of the two intermediates the following results were obtained:

P. cactorum, *P. citrophthora* and *P. palmivora* showed little growth in solution C or in solution C supplemented with one or both of the intermediates. In the thiamin solutions, however, all three grew slowly but continuously and at the end of a month had formed heavy colonies from 1.5 to 3 cm. in diameter. The dry weight of the mycelium from thiamin cul-

tures of *P. citrophthora* at the end of 51 days was 154 mg., while that in solution C or solution C supplemented with thiamin intermediates averaged 4.0 mg. *P. Boehmeriae*, *P. capsici*, *P. cinnamomi* and *P. parasitica* also failed to grow appreciably in the solutions lacking thiamin; they grew (more rapidly than the species already referred to) in the solutions which contained thiamin.

At the end of a month the colonies of *P. Boehmeriae* in the thiamin solution nearly filled the liquid and their average dry weight was 179.0 mgms. (fig. 1). Those in the solutions lacking thiamin were from 0.5 to 1.0 cm. in diameter and averaged 7.2 mg. The colonies of *P. capsici* also had filled the liquid of the thiamin cultures and averaged 419.6 mg. in dry weight. In the solutions lacking thiamin the colonies ranged from 0.5 to 1.0 cm. in diameter and averaged 0.3 mg. in dry weight.

P. cinnamomi grew rapidly in the solutions containing thiamin and the average dry weight after 30 days was 547.2 mg. In the solutions lacking thiamin the colonies ranged from 0.5 to 1.5 cm. in diameter and averaged 1.2 mg. (fig. 1). *P. parasitica* also grew in the thiamin solutions attaining an average dry weight of 114.2 mg. while in the solutions lacking thiamin the average dry weight was 0.4 mg. *P. fagopyri* grew well in the solutions containing thiamin, those containing pyrimidine and those containing the mixture of pyrimidine and thiazole (8). Little or no growth developed in solution C or solution C supplemented with thiazole.

From this experiment it appeared that the growth of at least seven species of *Phytophthora* was markedly improved by the addition of thiamin to the basic solution and but little affected by the addition of the intermediates singly or together. *P. fagopyri* differed from the other species in requiring for satisfactory growth thiamin or its intermediate pyrimidine. It appeared probable that the vitamin was the effective agent because we had used in some of the cultures thiamin which had been filtered sterile; this eliminated the possibility that the vitamin had been split into its intermediates in the sterilization.

It might be suggested, however, that the failure of these organisms to grow satisfactorily in the solutions containing the intermediates was the result of their toxicity at the concentrations used (30 units in 25 ml. solution); not to the inability of the fungi to utilize them.

Two species, *P. capsici* and *P. cinnamomi*, were, therefore, grown in (1), solution C and in the same solution supplemented with (2), 5 units of thiamin; (3), 5 units of thiamin and 30 units of thiazole; (4), 5 units of thiamin and 30 units of pyrimidine; (5), 5 units of thiamin and 30 units of both the thiazole and pyrimidine. The thiamin was filtered sterile and added to the solutions which had been sterilized by heat. Both species

grew rapidly in the solutions containing thiamin and no significant difference was observed between the growth in the presence of the thiamin alone and that in the solutions containing thiamin and its intermediates. This is shown by the dry weight of the mycelium in table 1. The growth in the solutions without thiamin was slight, probably at the expense of material present in the inoculum. In all other solutions it was heavy, the differences between the various solutions containing thiamin falling within the range of probable error.

The more rapid growth in this experiment was because purified asparagine was used in place of the commercial product. Some samples of the latter were found to contain injurious materials and even traces of thiamin or its intermediates. In order to eliminate the effect of the asparagine entirely solution D was used.

TABLE 1

Dry weights of mycelium per flask in solution C and in solution C supplemented with thiamin and its intermediates. Period of growth for P. cinnamomi 9 days, and for P. capsici 16 days.

SOLUTION / ORGANISM	DRY WT. (MG.) MYCELIUM IN SOLUTION C PLUS				
	Nothing	5 units thiamin	5 units thiamin 30 units thiazole	5 units thiamin 30 units pyrimidine	5 units thiamin 30 units each thiazole and pyrimidine
P. cinnamomi	0.3	334	264	302	297
P. capsici	2.0	152	166	160	178

The various species of *Phytophthora* were grown in (1), solution D and in solution D supplemented with (2), 5 units thiamin; (3), 5 units thiazole; (4), 5 units pyrimidine; (5), 5 units of both thiazole and pyrimidine, and in (6), the sugar solution without mineral salts or supplements. All species, except *P. fagopyri*, grew very little in solution D or in the solutions supplemented with one or both intermediates. The growth in the sugar solution was somewhat less than that in solution D. The growth in the thiamin solutions was several times that in solution D or solution D supplemented with one or both intermediates, though not nearly as great as in solutions containing asparagine. The dry weights are given in table 2.

The growth of *P. fagopyri* was about the same in solution D plus thiamin, plus pyrimidine or plus both intermediates (7 to 12 mg.) and distinctly more than in solution D, solution D plus thiazole or the sugar solution alone (3 to 4 mg.).

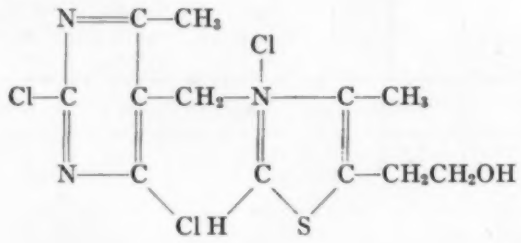
A compound resembling vitamin B_1 was secured through the courtesy of Andrew Bowman of Oxford University. As shown by the structural

TABLE 2

Dry weight of mycelium per flask in solution D plus 5 units of thiamin and in the same solution plus one or both intermediates or no supplements.

ORGANISM	DRY WT. MG. IN SOLUTION D PLUS		PERIOD OF GROWTH DAYS
	Thiamin	Plus intermediates or no supplement	
P. Boehmeriae	11.0	1	35
P. cactorum	6.0	1.5	27
P. cambivora	4.0	0.5	35
P. capsici	18.0	4.0	27
P. cinnamomi	52.0	5.0	27
P. citrophthora		not weighed	
P. cryptogea	41.0	0.3	35
P. Drechsleri	28.0	3.0	27
P. palmivora	11.0	0.3	35
P. parasitica	10.0	0.5	35

formula below the thiazole portion of the compound is identical with the vitamin thiazole but the pyrimidine portion is not.



Bowman's compound is ineffective as a substitute for thiamin. *Phycomyces*, however, is apparently able to split it into its components (10) and to combine the thiazole thus secured with a vitamin pyrimidine to form the essential thiamin (fig. 2). If we are correct in assuming that the species of *Phytophthora* studied here (except *P. fagopyri*) are unable to synthesize thiamin from its intermediates, then Bowman's compound with or without added vitamin pyrimidine should be ineffective. We have tested this hypothesis with one species only.

P. cinnamomi grew well in solution C supplemented with 5 units of thiamin, attaining a dry weight of 227 mg. in 11 days. In solution C, in solution C supplemented with 5 units of Bowman's compound or with 5 units of Bowman's compound and 10 units of the bromopyrimidine, little or no growth occurred. In the latter solutions the dry weight of the mycelium averaged between 0.3 and 0.9 mg. (fig. 2). The thiamin and Bowman's

compound were filtered sterile and added to the solutions which had been sterilized with heat.

DISCUSSION

Ten of the eleven species of *Phytophthora* studied apparently required an external supply of thiamin and were unable to utilize the intermediates of the vitamin. It appears that these fungi are unable to synthesize the vitamin from its intermediates as *Phycomyces Blakesleeanus* seems to do readily. The synthesis of the vitamin from its intermediates may be enzy-

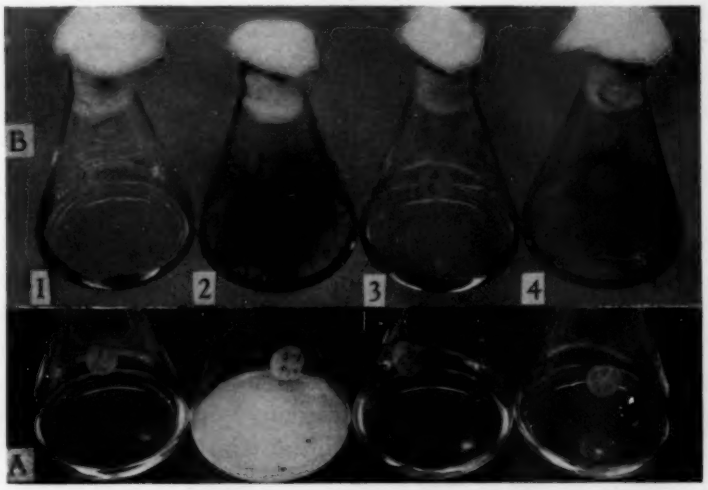


Fig. 2. Fungi grown in, (1) solution C and the same solution plus, (2) 5 units thiamin; (3) 5 units Bowman's compound; (4) 5 units Bowman's compound plus 10 units bromopyrimidine. A = *Phytophthora cinnamomi*, B = *Phycomyces Blakesleeanus*.

matic and these organisms may lack the necessary enzyme. *Phytophthora fagopyri*, on the other hand, seems able not only to synthesize thiamin from its intermediates but to form one of the intermediates from the more elementary materials of the medium (8). In view of the marked difference between the physiology of this species and the others studied, the question may be asked whether *P. fagopyri* is correctly placed in the genus *Phytophthora*.

Our results show that various species of *Phytophthora* are able to grow slowly in a medium which lacks organic nitrogen if the medium is supplemented by thiamin. Kögl and Fries (1) found similar results with *P. cactorum*. Reports that organic nitrogen (peptone for example) are required by these fungi and that inorganic nitrogen is unavailable are probably because the peptone supplies thiamin. Nevertheless, we secured much

greater growth in media containing asparagine than in one containing inorganic nitrogen only.

Our experience leads us to suggest that for work of the type discussed here commercial samples of asparagine should be purified. Repeated solution in water and precipitation with alcohol may be used. Unless precautions are taken with the asparagine erroneous conclusions may be drawn either because of the presence of toxic contaminants or because of the presence of appreciable amounts of thiamin or its intermediates.

Leonian (2, 3, 4, 5) was of the opinion that the accessory factor required by *P. cactorum* was not thiamin because his preparations were still active when treated in such a way as to destroy the vitamin molecule. It was thought that perhaps Leonian's results could be explained by the activity of the thiamin intermediates (8). However, in our experiments the vitamin alone and not the intermediates was effective. It would seem that the treatments used by Leonian did not destroy the vitamin, a substitute for thiamin exists which is more resistant or the intermediates are effective under conditions other than those we have used.

The discovery of organisms which apparently require an external supply of the vitamin itself, suggests the possibility of determining the presence of thiamin and estimating its amount by their use. In fact, it would appear possible to determine the vitamin and one or both intermediates by the use of suitable organisms. In order to use such a method successfully we need to know more of the relation between amount of vitamin supplement and growth of individual fungi, more of the specificity of thiamin and its intermediates and to use suitable means of eliminating the effect of toxic materials which may be present in natural materials. A scheme such as that given below is suggestive only, and even though found eventually to be impracticable from the standpoint of the actual determination, may be useful in showing the known relations of some fungi to thiamin and its intermediates.

I *Phytophthora cinnamomi*
Positive growth effect = thiamin
No growth effect = both intermediates or
pyrimidine alone or
thiazole alone or
no thiamin nor intermediates. See II

II *Phycomyces Blakesleeanus*
Positive growth effect = both intermediates
No growth effect = pyrimidine alone or
thiazole alone or
no thamin nor intermediates. See III

III *Phytophthora fagopyri*
Positive growth effect = pyrimidine alone

No growth effect = thiazole alone or
no thiamin nor intermediates. See IV

IV *Mucor Ramannianus*
Positive growth effect = thiazole alone
No growth effect = no thiamin nor intermediates.

SUMMARY

1. The following species of *Phytophthora* apparently required for growth an external supply of thiamin and were unable to use the thiamin intermediates: *Phytophthora Boehmeriae, P. cactorum, P. cambivora, P. capsici, P. cinnamomi, P. citrophthora, P. cryptogea, P. Dreschsleri, P. palmivora,* and *P. parasitica.*

2. A medium of mineral salts, asparagine, sugar and thiamin was much more favorable than one lacking asparagine.

3. *Phytophthora fagopyri* differed from the other species by growing in a medium supplemented with thiamin or its intermediate pyrimidine.

4. A scheme is suggested for determining thiamin or its intermediates by the use of suitable fungi.

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The winter buds of Brasenia

M. A. Chrysler[1]

(with eleven figures)

The water shield, *Brasenia peltata* Gmel. has long attracted attention on account of the extraordinary thickness of the gelatinous layer which invests the upper part of its stem, the petioles and lower surface of the leaf blades. The structure of the glandular hairs which secrete the "mucilage" has been described by Schrenk (1888) and Keller (1893), and the chemical nature of the secretion has also been investigated to a certain extent by the first author. Surmises concerning the function of the secretion have been made by Mrs. Arber (1920) and others. The development of the hairs has been worked out by Schrenk (l.c.).

But we have been unable to find any reference to the peculiar propagules or winter buds. This is the more surprising because of the wide distribution of the plant. They are really conspicuous objects as seen from a boat when one rows through a colony of the water shield during the autumn. Appearing as irregular shaped translucent reddish bodies 30–50 mm. in length, attached to the plant at a distance of a few decimeters below the surface of the pond, they at once attract attention. Perhaps these buds are not produced under all climatic conditions,[2] but on two occasions, September of 1930 and of 1936, the writer has collected them at the upper end of Lake Maranacook, Kennebec County, Maine. At this location, near the inlet of the lake, the water was from three to four feet deep, and the current was moderate. The occurrence of the plants was somewhat local, being apparently restricted to this part of the lake. A brief account of the morphology of the buds is presented.

The general features are illustrated in the habit photographs. Figure 1 shows a bud still attached to the parent plant, and not quite mature, while figures 2 and 3 show buds after they have become detached. It may be noticed that the lower end of the organ tapers to a blunt point. When the buds are mature the slightest touch dislodges them and they sink to the muddy bottom of the pond, in this respect resembling the winter buds of *Potamogeton crispus* which was described by Clos in 1856. This habit,

[1] The writer gratefully acknowledges the assistance of Mr. J. M. Seidman in preparation of the material.

[2] That these objects are not rare but need merely to be sought at the right time of year is indicated by the discovery of large numbers of them in Cranberry Lake, northern New Jersey, by my colleague, Dr. M. A. Johnson. This collection was made on October 17, 1937, about a month later in the season than the Maine collections, suggesting that the winter buds are formed when the temperature of a pond has fallen.

coupled with the exceedingly slippery nature of the abundant gelatinous covering, makes the collection of the buds an operation subject to many losses. A bud consists of a thickened stem, dwarf leaves with thickened petioles, and the gelatinous layer which envelops the whole organ with the exception of the upper surface of the leaves. Beneath this translucent coating the general color is reddish.

In order to contrast the structure of the winter bud with that of the normal shoot, it may be mentioned that the creeping stem of the latter gives off one or more slender ascending branches with nodes a few centimetres apart, from which spring the long slender petioles bearing floating blades. These are elliptical in shape, about 75×50 mm., and centrally peltate. Toward the end of the summer growth in length of a branch slackens, the internodes becoming successively shorter, but the diameter of the tip region of the stem increases from 2 mm. to as much as 5 mm., having more or less the form of an inverted cone. The visible leaves borne on this region are three or four in number, even five, the basal ones having blades 20-25 mm. long (or even 35 mm.), those near the apex 3–10 mm. long, with a few so small that they cannot conveniently be measured. All leaves of a bud develop very short petioles, hence the whole bud occupies a submerged position. The conduplicate vernation to which Miss Keller (1893) has called attention is quite conspicuous in the younger leaves of a bud. The petioles of these leaves are 2–2.5 mm., in diameter compared with

Explanation of figures

Fig. 1. Winter bud not quite mature, still attached to branch. Slightly reduced.

Fig. 2. Winter bud, detached. Slightly reduced.

Fig. 3. Another winter bud. Axillary buds are present. Slightly reduced.

Fig. 4. Long. section through base of a winter bud, showing a frequent appearance of the region of abscission. ×10.

Fig. 5. Trans. section of petiole of a winter bud. The double vascular bundle, cortical canals, storage tissue and abundant secretory hairs are shown. ×16.

Fig. 6. Trans. section of stem of a winter bud, on same scale as fig. 5. The two pairs of vascular bundles distinguish this organ.

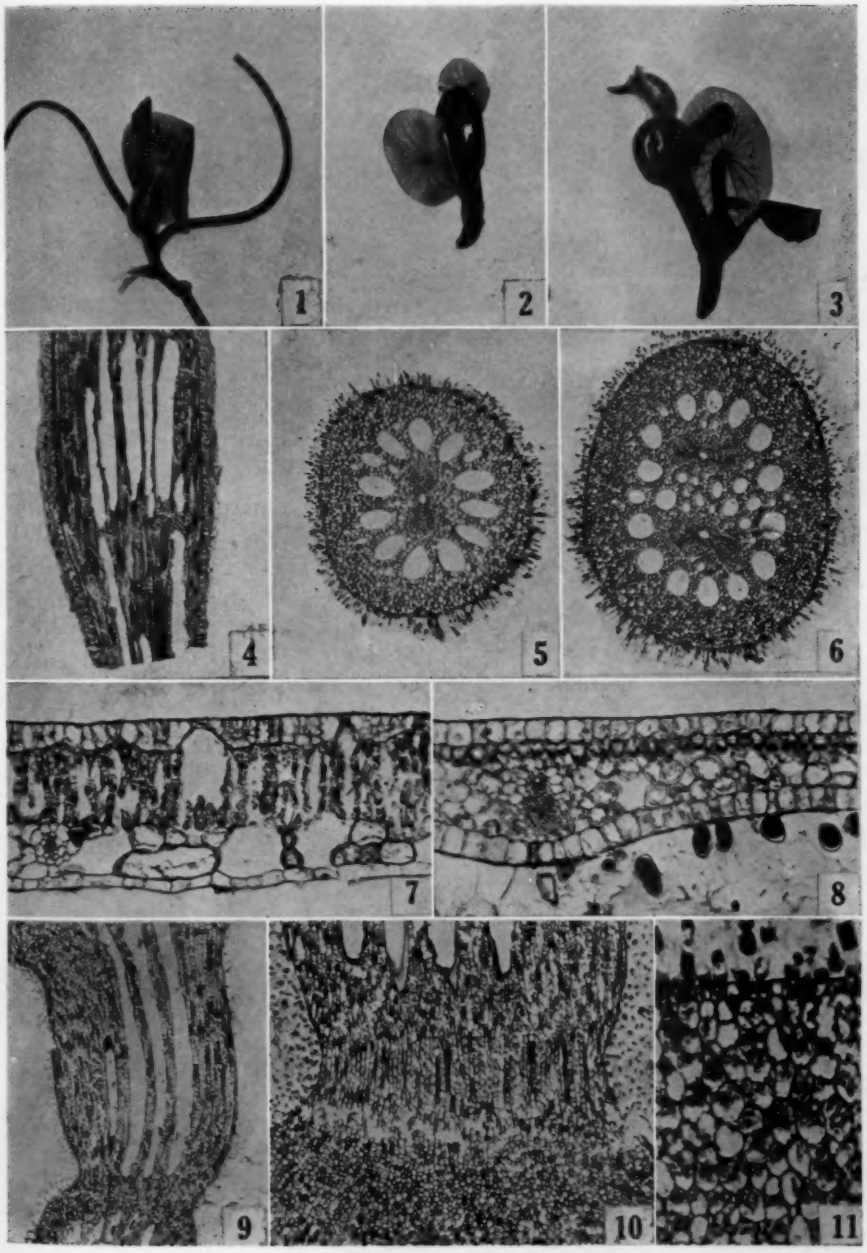
Fig. 7. Trans. section of normal leaf. The well-developed palisade and large space in the spongy tissue are shown. The section passes through one of the stomata with its large substomatal cavity. ×115.

Fig. 8. Trans. section of leaf of a winter bud. The poor development of the palisade and intercellular system, also absence of stomata, are indicated. ×115.

Fig. 9. Long. section of a winter bud through the region of abscission. ×10.

Fig. 10. Abscission region of another bud, showing breaking away of the cells. ×23.

Fig. 11. Portion of epidermis and cortex of stem of a winter bud, showing abundance of starch grains. ×80.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1.7–1.8 mm., for the normal leaves. Two or three of the basal leaves may have a well marked secondary bud in the axil. Most of these features are brought out in figures 1–3.

STRUCTURE OF THE WINTER BUD

Blade. The thickness of the blade of a bud leaf is about 0.17 mm., compared with 0.22 mm. in the floating leaf, that is, about three-fourths as thick. But the structure as brought out by figures 7 and 8 differs in several essential respects. The bud leaf has a more compact mesophyll, lacking extensive intercellular spaces, it entirely lacks the stomata which are characteristic of the upper surface of the floating leaf, and it has only one poorly developed palisade layer in place of the three layers found in the floating leaf. The cells representing the palisade layer are in the bud leaf very short cylinders about $37 \times 24\mu$, i.e., about 3:2, while each of the palisade cells of the floating leaf is about the same length but is only 10μ wide, i.e., nearly 4:1. Thus the tissues do not reach the extreme degree of reduction seen in the submerged leaves of certain species of *Potamogeton*, e.g., *P. pulcher* Tuckerm. The absence of stomata in the bud leaves is no doubt associated with the submerged position, while the compact tissues are adapted to storage rather than photosynthesis, for the abundant plastids are loaded with starch. The reddish color already mentioned is due to the presence of anthocyanin in certain of the cells. The secretory hairs occur only on the lower surface, and are exceedingly numerous, producing a layer of gelatin from two to three times as thick as the leaf.

Petiole. This organ is plainly given over to storage, as is shown by the large starch grains which replace chloroplasts. These grains occur in all tissues, although noticeably scarce in the phloem, in which region the grains are small. The proportion of solid tissues to intercellular canals is greater than in the floating leaves, in accordance with specialization for storage. The vascular tissues show the characteristic double phloem and single canal representing xylem. The abundance of secretory hairs may be made out in the photograph (fig. 5.)

Stem. Figure 6, from the same bud as the petiole of figure 5, is photographed at the same magnification. The structure is similar to that of the petiole except that in the stem a pair of the double vascular bundles are present. The large amount of starch stored in the cortical cells is shown in the more highly magnified photograph in figure 11. Again the profusion of secretory hairs is evident. These organs are quite scarce in the mature normal stem.

ABSCISSION

The ease with which the buds may be detached suggests that a mechanism for abscission may be present. Longitudinal sections through the base of a detached bud usually show a clean-cut lower end (fig. 4). looking as though the bud had been cut off by a knife. Sections through buds still attached show a well-marked constriction (fig. 9) at the region of abscission, without necessarily presenting a definite absciss-layer. But in another example, in which the bud was apparently just ready to drop off, zones immediately above and also below nodes were observed in which the cell-walls had changed their composition, as was shown by their taking the safranin stain in place of the fast green typical of the walls of the other internodal cells. Many of these altered cells were breaking down, as is shown in figure 10. Such a zone may be definitely identified as an absciss-layer, comparable to the layer developed by deciduous trees. Longitudinal sections through the base of a bud show the altered condition of cell-walls for some distance back of the break in the case of the phloem cells. These cells moreover are filled with a more or less granular substance which also takes the safranin stain.

TEMPERATURE RELATIONS

Normally, the buds rest during the winter on the muddy bottom of a pond, where the temperature would not fall below 4°C, on account of the slight current which would at any rate be present at the station in which the collections were made. An attempt was made to carry over some of the buds through the winter in the laboratory, by immersing them in a jar of water placed in an electric refrigerator. This material was kept in the refrigerator from September until March. Unfortunately the jar was shifted by an assistant to a position quite near the freezing element, with the result that the jar was found filled with ice. The temperature of the jar was slowly raised, and some days later the buds were transferred to a shallow glass dish and placed in a window. The buds soon softened and decayed. Obviously all that can be inferred is that the buds are killed by temperatures slightly below freezing point.

The result of this experiment corresponds with those of the extended investigation by Glück (1906), who tried the effect of various temperatures on a variety of winter buds, not including *Brasenia*, however.

GERMINATION

The object of our attempt to carry the buds over the winter was primarily to observe the growth from the bud after the resting period. The

only observations at present possible are due to the transfer of part of the material from the cold water of the Maine pond to the warmer water of the New Jersey water supply, which took place upon arrival of the material in the laboratory in September 1936. It was noticed that after lapse of a few days some of the buds showed an elongation of the terminal part of the axis, producing a slim shoot as yet devoid of normal leaves. This observation is definitely in contrast to the mode of "germination" shown in *Potamogeton crispus*, as reported and figured by Sauvageau (1893); in this plant the new shoots are produced in one or two of the axils of the winter bud. (A further attempt will be made to clear up the "germination" stages.)

NOMENCLATURE

Different terms have been proposed for what we have called "winter buds." "Hibernaculum" is a good but rather clumsy equivalent. The organs evidently belong to the category of "propagules," but this word does not express the whole idea. Mrs. Arber uses the term "turion" when referring to *Potamogeton crispus* (1920, p. 362). Glüuck (1906) appears to have been the first to use this term in the sense of the winter bud of an aquatic plant—a usage constituting a rather surprising extension of the meaning expressed for example in the definition of turion by Willis (1931): "a scaly sucker or shoot from the ground." At any rate Glück postulates the characters of the turions of water plants (p. 83), and proceeds to distinguish five classes, the distinctions based on whether the modified leaves represent a complete leaf, a petiole, or stipules. It is rather difficult to fit the winter bud of *Brasenia* into any of Glück's classes, because this bud is really a condensed apical part of a shoot rather than a scaly organ having the essential buds located in the axils of protecting scales. *Brasenia* on the contrary appears to depend largely on its thick coat of gelatin for what protection its buds need. In fact it is doubtful whether we should apply the term "turion" to the winter bud of this plant. Even then it corresponds to Glück's definition in two respects, viz., separation from the parent plant, and germination apart from the parent.

SUMMARY

In autumn *Brasenia* produces condensed apical organs which are here called "winter buds." With their heavy coating of gelatinous material they are detached from the parent plant by means of an absciss-layer, and fall to the bottom of the pond where they spend the winter. The form and

internal structure of these organs are described. The application of the term "turion" to these winter buds is discussed.

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Notes on Myxophyceae, I—IV[1]

FRANCIS DROUET

In these Notes, herbaria in which specimens are cited are indicated by the following abbreviations: D, my personal herbarium; F, Farlow Herbarium of Harvard University; G, Herbarium of Goucher College; L, Rijksherbarium, Leiden; Mo. Missouri Botanical Garden; N, New York Botanical Garden; S, Naturhistoriska Riksmuseet, Stockholm; T, Herbarium of Wm. Randolph Taylor. This work was done in part at Yale University with the aid of the Theresa Seessel Research Fellowship.

I. NOMENCLATURAL CONSIDERATIONS

Johannesbaptistia pellucida (Dicki) W. R. Taylor & Drouet, comb. nov. *Hormospora pellucida* Dickie, Journ. Linn. Soc. Bot. **14:** 365 (1874). *Cyanothrix primaria* Gardn., Mem. New York Bot. Gard. **7:** 31, pl. 6, f. 57 (1927). *C. Willei* Gardn., loc. cit., pl. 6, f. 58 (1927). *Nodularia? fusca* W. R. Taylor, Carnegie Inst. Wash. Papers Tortugas Lab. **25:** 48, pl. 1, f. 23 (1928). *Johannesbaptistia primaria* DeToni f., Noterelle nomencl. algolog. **1:** 6 (1934); Drouet descr. emend., Univ. So. Calif. Publ. Hancock Pacific Exped. **3:** 16, pl. 2, f. 3, 4 (1936). *J. Willei* DeToni f., loc. cit. (1934). *J. Gardneri* Frémy, Bull. Soc. Hist. nat. Afr. Nord **26:** 95, pl. x (1935).—Specimens examined: BRAZIL: in rock pools, mixed with *Cladophora* &c., Fernando de Noronha, *H. N. Moseley* [*Challenger Expedition*] *No. 22* (Type of *Hormospora pellucida* in British Museum). VIRGIN ISLANDS: lagoon, Charlotte Amalie, *W. A. Hoffman 146593*, Sept. 1937 (D, T). PUERTO RICO: San Juan, Lake Tortuguero, *N. Wille 830b* (TYPE of *Cyanothrix primaria*), *830e* (TYPE of *C. Willei*), *844e*, *849c*, 5 Feb. 1915 (all in Herb. New York Bot. Gard.). FLORIDA: Dry Tortugas, among other filamentous algae, *W. R. Taylor*, July 1925 (TYPE of *Nodularia? fusca* in Herb. W. R. Taylor) ECUADOR: Galapagos Islands, Isabela Island, *W. R. Taylor 123*, 12 Jan. 1935 (D); Fernandina Island, *Taylor 155*, 14 Jan. 1935 (D). CALIFORNIA: in brackish water west of Newport Beach, *G. J. Hollenberg 1533e*, 26 Sept. 1934 (D, Hollenberg).

During a visit in London in 1937, Prof. Wm. R. Taylor discovered the original material of *Hormospora pellucida*, recognized its similarity to his own *Nodularia? fusca*, and at once communicated his notes to me. More recently, through the great kindness of Messrs. G. Tandy and J. Ramsbottom of the British Museum (Natural History), I was permitted to

[1] Contribution from the Osborn Botanical Laboratory of Yale University and from the Department of Botany, Marine Biological Laboratory.

to examine a portion of this same material. The filaments are excellently preserved and match in every respect those of the types of *Cyanothrix primaria* and *C. Willei*. Prof. G. J. Hollenberg has obligingly sent me material of his collection from California cited above. Frémy (loc. cit.) and Seurat & Frémy, idem **28:** 294 (1937), have reported specimens answering to the description of this species from Tunisia, Algeria, and the Dutch West Indies under the superfluous name (cf. Art. 50 of the present International Rules) *J. Gardneri*. In view of its very wide distribution in saline waters of tropical and subtropical regions of the earth, we should not be surprised to discover that this species had been recognized and described at a date far earlier than 1927, when *C. primaria* Gardn. was published.

SCHIZOTHRIX MEXICANA Gom., Ann. Sci. nat. VII Bot **15:** 304 (1892). *Lyngbyopsis Willei* Gardn., Mem. New York Bot. Gard, **7:** 55, pl. 11, f. 1 (1927).—Specimens seen: PUERTO RICO: on rocks in a brook 5 km. north of Utuado, *N. Wille 1597*, 8 Mar. 1915 (TYPE of *Lyngbyopsis Willei* in Herb. New York Bot. Gard.). JAMAICA: on rock in 'Wag Water,' Castleton, *J. E. Humphrey*, 12 Apr. 1893 (F, G).

The type of *L. Willei* represents truly a species of Schizothrix and answers in every respect to Gomont's description of *S. mexicana*. The sheaths are thin and very hyaline, but their nature is easily demonstrated when colored blue by treating with chlor-zinc-iodine[2] or when stained lightly with dilute solutions of various dyes. Even after long and meticulous searching in the type material, I am unable to discover the interwoven branching of filaments described as peculiar to the monotypic genus *Lyngbyopsis* Gardn. (ibid. 54). Hormogonial masses are present, and it is possible that the branching of filaments in such masses was studied in an unstained condition. Unfortunately I have not had the opportunity to examine authentic material of *S. mexicana* annotated by Gomont; but there can be little doubt, judging from Gomont's description, that the two types are similar. The Jamaican collection cited above is the one reported by Collins in Proc. Amer. Acad. **37:** 240 (1901).

PHORMIDIUM PENICILLATUM[3] Gomont in Jadin, Bull, Soc. Bot. France **40:** clix (1893). *Symploca profunda* W. R. Taylor, Carnegie Inst. Wash. Papers Tortugas Lab. 25: **47,** pl. 1, f. 18 (1928). *Oscillatoria maricola* Gardn., New York Acad. Sci. Sci. Surv. Porto Rico **8:** 270, pl. 1, f. 3 (1932).—Specimens examined: FLORIDA: dredged, White Shoal Sta. 3, Dry Tortugas, *W. R. Taylor 254*, 11 July 1924 (TYPE of *Symploca profunda* in

[2] For the method of employing this reagent in Myxophycean studies, see Drouet, Amer. Journ. Bot. **24:** 604, footnote 7 (1937).

[3] The original spelling is 'penicellatum.'

Herb. W. R. Taylor); dredged, Loggerhead Key, Dry Tortugas, *Taylor 284*, 12 July 1924 (T); dredged beyond Southwest Channel in 20 fathoms, Dry Tortugas, *Taylor 723*, 11 June 1925 (T). PUERTO RICO: Culebra Island, *M. A. Howe 4366*, 7 Mar. 1906 (N); Muertos Island (Caja de Muertos), *Howe 7479*, 8 July 1915 (TYPE of *Oscillatoria maricola* in Herb. New York Bot. Gard.); east of mouth of Guanica Harbor, *Howe 7311*, 1 July 1915 (N); dredged, mouth of Guanica Harbor, *Howe 7446*, 4 July 1915 (N). JAMAICA: 'Blue Hole,' shaded shallow water, *A. E. Wight*, 26 May 1906 (det. Gomont: D, F, S).

The two species proposed here as synonyms of *P. penicillatum* are based upon morphologically similar types, and I am unable to find characters to separate these types from the Jamaican specimens annotated by Gomont as *P. penicillatum*. All the specimens cited above consist of penicillate plant masses from salt water, principally below low tide level; the cells have rose- or violet-colored protoplasm and are usually longer than broad; the calyptra of the apical cell is rather inconspicuous and rotund or depressed-conical. Gomont's type from Réunion was described as having trichomes 6μ in diameter; the Antillean material seen here has trichomes ranging from 5.5μ to 9μ in diameter.

II. MYXOPHYCEAE FROM COSTA RICA

A small package of blue-green algae from Costa Rica was recently sent to me for study by Dr. Carroll W. Dodge of the Missouri Botanical Garden. I interpret the specimens as follows, listing them under specific names according to provinces:

CALOTHRIX CONTARENII (Zanard.) Born. & Flah., Ann. Sci. nat. VII Bot. **3:** 355 (1886).—One collection on wood in salt water, PUNTARENAS: along seashore between Río Sándoval and Río Tigre, *Dodge 4357*, 1 May 1930 (D, Mo).

CALOTHRIX PILOSA Harv. ex Born. & Flah., ibid. 363 (1886). *Tildenia pilosa* Polj., Bull. Jard. Bot. Princip. U.S.S.R. **27:** 227 (1928). *Setchelliella pilosa* DeToni f., Noterelle nomencl. algolog. VIII (1936).—On wood in salt water, PUNTARENAS: along seashore between Río Sándoval and Río Tigre, *Dodge 4537A*, 1 May 1930 (D, Mo).

FREMYELLA VITIENSIS (Born. & Flah.) DeToni f., loc. cit. (1936). *Microchaete vitiensis* Ask. ex Born. & Flah., ibid. **5:** 84 (1887).—Marine, PUNTARENAS: along seashore between Río Sándoval and Río Tigre, *Dodge*, 1 May 1930 (D, Mo).

SCYTONEMA HOFMANNII Ag. ex Born. & Flah., ibid. 97 (1887).—On tree trunks, often somewhat lichenized. ALAJUELA: la Palma de San Ramón, *A. M. Brenes 176, 177*, 12 Nov. 1920 (D, Mo). LIMON: on

Croton at house, Hamburg Farm, *Dodge & F. Nevermann 7454*, 31 Mar. 1930 (Mo).

SCHIZOTHRIX THELEPHOROIDES (Mont.) Gom., idem **15:** 319, pl. x, f. 1–4 (1892).—On soil and mixed with other algae, mosses, and lichens, ALAJUELA: Alto del Mendongo del San Ramón, *A. M. Brenes 285*, 9 Jan. 1930 (D, Mo).

OSCILLATORIA ANIMALIS Ag. ex Gom., ibid. **16:** 227, pl. vii, f. 11 (1892). —On wet mosses with juvenile *Nostoc* sp., SAN JOSE: potreros of Rancho Redondo, *Dodge & W. S. Thomas 5267*, 18 Nov. 1929 (D, Mo).

III. MYXOPHYCEAE FROM ARGENTINA

During the period November 1936 until January 1937, Dr. Stillman Wright was engaged in a limnological survey of some freshwater lakes of central Argentina, under the joint auspices of the División de Piscicultura of Argentina and the Commissão Technica de Piscicultura of Brazil. His formalin-preserved material, sent to me for study and distribution, consists of the following specimens, cited geographically under the specific names according to provinces. Serial numbers of collections in italics are to be understood as those of Dr. Wright.

MICROCYSTIS AERUGINOSA Kütz., Tab. phyc. **1:** 6, Tab. 8 (1845–49).—Abundant in the plankton of many lakes, BUENOS AIRES: Laguna Los Chilenos near Dufaur, *2113*, 11 Jan. (D); Laguna Blanca Grande, *2098*, 14 Jan. (D, F, L, N, S); Laguna Chascomus, *2101*, 11 Nov. (D). SAN LUIS: with *Phormidium mucicola*, Laguna Tala, *2111*, 10 Dec. (D, F, L, S); with *P. mucicola*, Laguna Garcia, *2096*, 7 Dec. (D, L, N, S); with *P. mucicola*, Laguna La China, *2112*, 4 Dec. (D, L, N, S); with *P. mucicola*, Primera Laguna, *2059*, 4 Dec. (D).

CALOTHRIX PARIETINA (Näg.) Thur. ex Born. & Flah., Ann. Sci. nat. VII Bot. **3:** 366 (1886).—In an incrustation on a fish tank, BUENOS AIRES: Chascomus, *2102*, 19 Nov. (D, F, L, N, S).

GLOEOTRICHIA NATANS (Hedw.) Rabenh. ex Born. & Flah., ibid. **4:** 369 (1886).—One collection, SAN LUIS: Laguna Viejo, *2094*, 8 Dec. (D, F, L, N, S).

ANABAENA ?FLOS-AQUAE (Lyngb.) Bréb. ex Born. & Flah., ibid. **7:** 228 (1888).—The material is without spores, and I therefore assign the specific name with some uncertainty. Forming a considerable part of the plankton from one lake, SAN LUIS: Tres Lagunas (No. 3), *2110*, 6 Dec. (D, F, L, N, S).

APHANIZOMENON FLOS-AQUAE (L.) Ralfs ex Born. & Flah., ibid. 241 (1888).—From the plankton, BUENOS AIRES: Laguna Carlito, Necochea, *2093*, 17 Jan. (D, F, L, N, S).

PLECTONEMA NOSTOCORUM Born. ex Gom., idem **16:** 102, pl. i, f. 11 (1892).—With *Calothrix parietina* in an incrustation on a fish tank, BUENOS AIRES: Chascomus, *2102*, 19 Nov. (D, F, L, N, S).

PHORMIDIUM MUCICOLA Naum. & Huber in Huber-Pestalozzi & Naumann, Ber. d. d. bot. Ges. **47:** 68, f. 1–6 (1929).—I discuss the occurrence of this species in North America in a current number of Rhodora (1938). In the Argentine lakes it is abundant within the sheaths of *Microcystis aeruginosa*, but wholly absent in collections from some of the lakes. BUENOS AIRES: Laguna Los Chilenos near Dufaur, *2113*, 11 Jan. (D). SAN LUIS: Laguna La China, *2112*, 4 Dec. (D, L, N, S); Laguna Tala, *2111*, 10 Dec. (D, F, L, S); Laguna Garcia, *2096*, 7 Dec. (D, L, N, S).

OSCILLATORIA PRINCEPS Vauch. ex Gom., ibid. 206, pl. vi, f. 9 (1892). *Lyngbya gigantea* Lewis, Zirkle & Patrick, Journ. Elisha Mitchell Sci. Soc. 1933: 221 (1933).—Two collections, CÓRDOBA: creek near city of Córdoba, *2116*, 21 Dec. (D, F, L, N, S); Laguna Embolse Rio III, Almafuerte, *2115*, 18 Dec. (D, L, N, S).

OSCILLATORIA ANGUINA Bory ex Gom., ibid. 214, pl. vi, f. 16 (1892). *Phormidium Chungii* Gardn.,[4] Univ. Calif. Publ. Bot. **14:** 4, pl. 1, f. 5 (1927).—One collection: CÓRDOBA: Laguna Embolse Rio III, Almafuerte, *2091*, 16 Dec. (D, F, L, N, S).

OSCILLATORIA OKENI Ag. ex Gom., ibid. 232, pl. vii, f. 18 (1892).—Specimens seen: BUENOS AIRES: Australian tank, Estancia "La Lola," Dufaur, *2092*, 13 Jan. (D, F, L, N, S). SAN LUIS: Laguna El Sarco, *2106*, 7 Dec. (D). CÓRDOBA: with *O. anguina*, Laguna Embolse Rio III, Almafuerte, *2091*, 16 Dec. (D, F, L, N, S).

OSCILLATORIA CHALYBEA Mert. ex Gom., ibid. 232, pl. vii, f. 19 (1892); Borge, Ark. f. Bot. **6**(4): 11 (1906).—Specimens seen from Argentina: JUJUY: with *Phormidium laminosum*, Quinta, in aqua 36.5° [C], *R. E. Fries* (*Regnell Expedition*) *No. 9*, 12 June 1901 (S). CÓRDOBA: with *O. anguina*, Laguna Embolse Rio III, Almafuerte, *2091*, 16 Dec. (D, F, L, N, S).

OSCILLATORIA SPLENDIDA Grev. ex Gom., ibid. 224, pl. vii, f. 7–8 (1892).—BUENOS AIRES: with *O. Okeni*, Australian tank, Estancia "La Lola," Dufaur, *2092*, 13 Jan. (D, F, L, N, S).

SPIRULINA PLATENSIS (Gom.) Geitl., Rabenh. Kryptogamen-Fl. **14:**

[4] The trichomes of the TYPE of *P. Chungii* in the Farlow Herbarium (CHINA: Fulung Hot Springs, Tanggate, Foochow, *Chung A452*) are indistinguishable from those of other specimens placed under the name *O. anguina* in my herbarium. The trichomes are mixed with filaments of other sheathed Myxophyceae, but I am unable to demonstrate sheath material (except in hormogonial masses) belonging properly to *P. Chungii*.

925, f. 589, 590 (1932). *Arthrospira platensis* (Nordst.) Gom., ibid. 247, pl. vii, f. 27 (1892). *S. Jenneri* var. *platensis* Nordst. ex Gom., loc. cit. (1892); Nordst. in Wittr. & Nordst., Alg. exs. **14:** 679 (1884), in Farlow Herb.—The original material of this species was collected in Uruguay by Arechavaleta and distributed in the exsiccata noted above. Several workers have since reported collections from Africa. Miss Rich in Rév. algol. **6**(1): 75–79 (1931) has given us detailed observations upon her material from Kenya Colony. She reports that in a considerable number of individuals the trichomatal dimensions vary within a much wider range than that noted in Gomont's description. Gomont, of course, based his diagnosis upon a single dried collection from another continent. As did the African collections, the material cited here comes from highly alkaline lakes: SAN LUIS: with *Anabaena ?flos-aquae*, Tres Lagunas (No. 3), *2110*, 6 Dec. (D, F, L, N, S); Laguna El Chorriado, *2089*, 10 Dec. (D, F, L, N, S).

SPIRULINA MAJOR Kütz. ex Gom., ibid. 251, pl. vii, f. 29 (1892). *S. densa* Lillick, Amer. Midl. Nat. 16: 210, f. 1A (1935).—Two collections: BUENOS AIRES: with *Oscillatoria Okeni*, Australian tank, Estancia "La Lola," Dufaur, *2092*, 13 Jan. (D, F, L, N, S). SAN LUIS: Laguna El Sarco, *2106*, 7 Dec. (D).

IV. NORTH AMERICAN MYXOPHYCEAE IN THE SCHWEINITZ HERBARIUM

During a recent visit at the Academy of Natural Sciences in Philadelphia, Dr. F. W. Pennell and Dr. Ruth Patrick invited me to look through the rather large algal collections of Dr. Lewis David von Schweinitz (1780–1834). The Myxophyceae, although few in number, are chiefly freshwater forms collected in the vicinity of Winston-Salem, North Carolina, presumably between the years 1812 and 1821; some specimens come from other states. Few data appear upon the specimens themselves; beyond a generic or specific name, there is usually only a terse note "Salem" for what is now Winston-Salem, "Virg" for Virginia, "Beth" for Bethlehem, Pennsylvania, etc. Drs. Pennell, Schallert, Benedict, and Barnhart have given us an enlightening symposium on the life and collections of Dr. Schweinitz in Bartonia **16:** 1–36 (1934). In his unpublished manuscript,[5] "Flora Salemitana" (dated 1821), now on file in the Herbarium of the Academy, Schweinitz has mentioned most of the North Carolina specimens by name and has given a few notes on the locality and habitat of each. In preparing the labels and in citing in the enumeration below, I have included all such information from the above sources as could with some degree of certainty be attached to the specimens individually. In the collection also are specimens of no inconsiderable his-

[5] See Pennell in Bartonia **13:** 50–52 (1931).

torical interest communicated to Schweinitz by his friend and correspondent, Dr. John Torrey. These are indicated most often by the simple annotation "Torrey," sometimes with a transmittal number, sometimes with more exact data.[6] In the list below, all specimens cited are to be found in the Herbarium of the Academy at Philadelphia and, unless otherwise indicated, are to be understood as collected by Schweinitz himself.

NOSTOC COMMUNE Vauch. ex Born. & Flah., Ann. Sci. nat. VII Bot. **7:** 203 (1888).—NORTH CAROLINA: as *N. commune*, common at certain seasons upon the earth, Winston-Salem.

NOSTOC PRUNIFORME (L.) Ag. ex Born. & Flah., ibid. 215 (1888).—PENNSYLVANIA: as "*N. crepitans* Nobis," Bethlehem.

NOSTOC VERRUCOSUM (L.) Vauch. ex Born. & Flah., ibid. 216 (1888).—VIRGINIA: as *N. Botrydium*.

SCYTONEMA GUYANENSE (Mont.) Born. & Flah., ibid. **5:** 94 (1887).—UNITED STATES: as *S. atrovirens*, on rocks, *comm. Torrey*. NORTH CAROLINA: as *Conferva ebena*, Winston-Salem.

PORPHYROSIPHON NOTARISII (Menegh.) Kütz. ex Gom., idem **15:** 331, pl. xii, f. 1, 2 (1892).—For a discussion of the morphology and recent synonymy of this species, see Drouet in Amer. Journ. Bot. **24:** 601 (1937). NORTH CAROLINA: as *Conferva ericetorum*, on the earth, red, Winston-Salem.

LYNGBYA CONFERVOIDES Ag. ex Gom., ibid. **16:** 136, pl. iii, f. 5, 6 (1892).—UNITED STATES: as *Bangia atropurpurea*, sea shore, *comm. Torrey 189*.

LYNGBYA OCHRACEA (Kütz.) Thur. ex Gom., ibid. 149 (1892).—NORTH CAROLINA: in most metallic springs—this from near Pilot [Mountain], near Winston-Salem.

PHORMIDIUM TRELEASEI Gom., Bull. Soc. Bot. France **46:** 37 (1899).—The one collection[7] comes from the type locality of the species, ARKANSAS: as *Oscillatoria calida*, hot springs of the Washita [now Hot Springs, near the Ouachita River], 150° F, *comm. Torrey*.

PHORMIDIUM INUNDATUM Kütz. ex Gom., Ann. Sci. nat. VII Bot. **16:** 172, pl. iv, f. 31, 32 (1892). *P. purpurascens* var. *elegans* Drouet,[8] Bot. Gaz.

[6] The correspondence of Schweinitz and Torrey has been published in fairly complete form in Mem. Torr. Bot. Club **16**(3) (1921). Unfortunately, lists of collections exchanged between the two men have been omitted; and I have not had the opportunity to hunt for further data on the Torrey specimens among the letters themselves.

[7] It is not clear whether Thomas Nuttall, Thomas Drummond, or Zina Pitcher collected this material. See Mem. Torr. Bot. Club **16:** 137, 151, 248, 277, 279 (1921).

[8] The TYPE of *P. purpurascens* var. *elegans* in my personal herbarium (MISSOURI: in a spring at east side of Highway 28 at Gasconade River Bridge, Pulaski

95: 696, f. 3 (1934).—NORTH CAROLINA: as *Oscillatoria fontinalis*, rare in springs on stones, Winston-Salem.

PHORMIDIUM RETZII (Ag.) Gom., ibid. 176, pl. v, f. 6–9 (1892).—NORTH CAROLINA: as *Conferva*, Winston-Salem.

PHORMIDIUM SETCHELLIANUM Gom., ibid. 190, pl. v, f. 25, 26 (1892).—It is unfortunate that we have no further data on this collection, for the species is known to me only in specimens from New England. UNITED STATES: as *Oscillatoria Friesii, comm. Torrey 353.*

PHORMIDIUM FAVOSUM (Bory) Gom., ibid. 180, pl. v, f. 14, 15 (1892).—UNITED STATES: as *Oscillatoria fusco-purpurea, comm. Torrey 161.* NORTH CAROLINA: as *O. fontinalis*, rare in springs on stones, Winston-Salem.

PHORMIDIUM UNCINATUM (Ag.) Gom., ibid. 184, pl. v, f. 21, 22 (1892).—NORTH CAROLINA: as *Oscillatoria flexuosa*?, Winston-Salem.

PHORMIDIUM AUTUMNALE (Ag.) Gom., ibid. 187, pl. v, f. 23, 24 (1892). *Lyngbya hahatonkensis* Drouet, Bot. Gaz. **95:** 698, f. 5 (1934).—NORTH CAROLINA: as *Oscillatoria vaginata*, on the staircase of Barhouse, Winston-Salem.

OSCILLATORIA LIMOSA Ag. ex Gom., ibid. 210, pl. vi, f. 13 (1892).—NORTH CAROLINA: as *O. flexuosa*?, Winston-Salem; as *Conferva canalicularis*, a handsome one in Stotz bottom garden, Winston-Salem.

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County, *Drouet 1033*, 1 Oct. 1932) differs in no respect from the specimen of *P. inundatum* examined by M. Gomont in the Farlow Herbarium, MAINE: on water trough, Eastport, *W. G. Farlow*, Sept. 1877. The violet-black color of the plant mass as described in the original publication of the var. *elegans* is evident only when the mass is observed beneath the surface of the water: out of the water, the color is quite blue-green.

Notes on Maryland algae[1]

HAROLD C. BOLD
(WITH PLATES 6 AND 7)

From 1934 through 1937 the author was resident for six weeks each summer at the Chesapeake Biological Laboratory which is located on Solomons Island, Calvert County, Maryland. The following paper contains notes on a study of the algae of that region and descriptions of new species, of forms new to the United States or significant for some other reason. The organisms discussed below are all fresh-water forms and are treated according to the classification given by Smith (1933); all belong to the order Volvocales.

POLYBLEPHARIDACEAE

PYRAMIMONAS MONTANA Geitler (figs. 1–12).—Although eight species of this genus have been described from abroad (Pascher, 1927), but two have been recorded as present in the algal flora of this country. Smith (1933) reports finding *P. tetrarhyncus* Schmarda from Wisconsin lakes and earlier Prescott (1926) reported *P. inconstans* Hodgetts from Iowa. During the past four summers small puddles in the clay mud of a barnyard at Solomons became colored a brilliant green due to the presence of such organisms as *Pandorina morum* Bory, *Eudorina elegans* Ehr., *Chlamydobotrys stellata* Korsch.; during periods of intense sunlight a bright green cloud of organisms gathered near the surface of the most intensely illuminated portion of each pool and microscopic examination revealed that these streaks consisted practically entirely of *Pyramimonas* sp. Attempts to cultivate the organism have been unsuccessful; preparation of stained slides has been only partially successful and efforts to preserve the organism have failed because of the absence of a cell wall. The pools containing the organism are supplied with water from an artesian well which runs into a trough and overflows on the surrounding clay. At times pools become completely dry but following rains they again become populated with *Pyramimonas* and the associated organisms.

Figures 1–12 illustrate the organism, which seems to be identical with *P. montana* Geitler (Geitler, 1925). The cells are bluntly conical and swim with the base of the cone directed forward. Most of the individuals are slightly four lobed or ridged at the anterior end (figs. 1, 2) but there are all gradations from this condition to cells with almost truncate anterior poles (fig. 12). In ridged individuals there is a depression in the center of the anterior end among the ridges in which the flagella are inserted. The

[1] Contribution Number Sixteen from the Chesapeake Biological laboratory.

cells are rounded in end view and optical transverse section and taper symmetrically toward the posterior. Cell size in my specimens varies from 12 to 20 microns in length and from 8 to 16 microns in width at the broadest point; Geitler's specimens varied from 17 to 22.5 microns. The cells move very rapidly forward turning on their long axes and when they strike another object they rapidly reverse the direction of their movement without reversing the orientation of their bodies. Four flagella are attached to the central region of the anterior end of the cell and are about as long as the length of the cell body. Treatment with weak iodine solution or osmic acid vapor reveals the presence of a small but distinct blepharoplast to which the flagella are attached in such a way that they appear to diverge at approximately 90° angles when the cell is at rest (figs. 3, 8–10). A cell wall is lacking and the cells are therefore somewhat metabolic as indicated by changes in shape when two individuals collide.

On either side of the blepharoplast a contractile vacuole is visible in the living cells (figs. 1, 2, 3 etc.); these contract and expand alternately. The chloroplastid is cup shaped and massive and appears to fill the cell in surface view. In longitudinal optical section it becomes apparent that there is a shallow region of colorless cytoplasm at the posterior pole of the cell in which the nucleus is visible (figs. 2, 5, 7). The chloroplastid in living cells is highly granular and contains scattered starch grains and oil droplets. When the cell is ridged the chlorophyll-bearing cytoplasm extends out into the ridges anteriorly. Deep within the chloroplastid in the basal region of the cell a single pyrenoid is usually embedded; it is rarely entire (figs. 1, 2), usually consisting of a number of fragments or portions (figs. 5, 8, 11). The pyrenoid is usually surrounded by a ring of small starch grains (figs. 1, 2); figure 5a represents a compound pyrenoid as it appears in a cell stained with iodine; each portion consists of a proteinaceous portion, at the periphery of which occurs a violet-stained starch grain. Other starch grains which presumably originate around the pyrenoid, occur in other regions of the chloroplastid.

The nucleus lies in the region of colorless cytoplasm within the chloroplastid and is distinctly pear-shaped (figs. 8, 11); the beak of the nucleus extends between the two contractile vacuoles and lies beneath the blepharoplast. In my specimens the nucleus was not visible in the living cells but became sharply defined when the cells were moribund or when treated with osmic acid, iodine or with haematoxylin after fixation. Each nucleus contains a single large spherical nucleolus and in stained preparations there is some evidence of the presence of a chromatin network.

Hanging drop mounts did not remain in good condition for more than forty-eight hours, probably due to lack of oxygen and to the multiplication

of numerous bacteria. In such cultures some individuals disintegrated, while others rounded up, became enveloped in a thick gelatinous wall, and apparently entered into a period of dormancy (fig. 4).

Multiplication consists of the longitudinal division of one cell into two; dividing individuals were encountered most frequently in collections made late in the afternoon. No details of nuclear division were obtained in fixed preparations; Geitler (1925) figures one stage which indicates that it is mitotic. Aside from actual cleavage there are two criteria which indicate impending cell division. The pyrenoid, whether simple or fragmented, becomes elongated in a plane at right angles to the long axis of the cells (fig. 6). As the time for cytokinesis approaches the elongated mass is gradually separated into two portions (figs. 7, 8) which form the pyrenoids of the daughter cells (figs. 10, 11). A second indication of approaching division is the gradual increase in the number of flagella. The cell figured as 5 had six flagella two of which were shorter and were apparently growing out from the blepharoplast in anticipation of cleavage. Many individuals with eight flagella were seen (figs. 7, 8) in collections examined late in the afternoon and evening, but by the following morning all cells in the culture were again quadriflagellate indicating that cell division had been completed. The cells apparently begin to increase the number of flagella long before cytokinesis is completed or even initiated. In division, as observed in living cells, the flagella begin to diverge into two groups of four as the anterior pole of the cell broadens (figs. 7, 8) and since the contractile vacuoles also diverge growth probably occurs most actively in the region just between them. Each daughter cell therefore receives one contractile vacuole from the mother cell. The posterior portion of the cell subsequently increases in size and a cleavage furrow appears in it (fig. 8). Similarly a furrow is initiated between the groups of diverging flagella and when the furrows meet, cell division is complete. Cells which are still incompletely segregated already contain two contractile vacuoles each (fig. 9), so that one must arise *de novo* very quickly in each. Figure 10 illustrates one product of a recent cell division fixed with osmic vapor. As in other species of the genus, cell division occurs while the organism is motile. The organism described above appears to be very close to Geitler's (1925) *Pyramimonas montana* which he found in an Alpine pool at an altitude of five thousand feet. In *P. montana* Geitler reports that the ratio of length to breadth is that of 2:1 or slightly less than 1; in the Maryland organism it is approximately 8:5, but occasional relatively longer individuals occur. Geitler states that his species was pale yellowish in color while the organisms I observed were a deep grass-green. It is well known however that differences in mineral content of the medium profoundly

affect the intensity of the pigmentation. The Maryland organisms therefore should probably be considered as a form of *P. montana* Geitler; it is here reported for the first time from the United States.

CHLAMYDOMONADACEAE

CARTERIA CRUCIFERA Korsch. (figs. 16–17).—This organism occurred in considerable abundance during the summer of 1935 in a small lily pool in the garden of a residence at Solomons Island. It has not been seen in succeeding summers but as the drawings indicate it is undoubtedly identical with *C. crucifera* Korsch.[2] The cells among my specimens vary from a minimum of 10μ to a maximum of 20 in length; Korschikoff reports individuals up to 27μ in length. The outstanding character of the species is the cruciform arrangement of the flagella which originate from the prominently four-parted papilla. The pyrenoid lies on the median longitudinal axis of the cell, deep within the chloroplastid. The latter is cup-shaped, sometimes open also posteriorly and is characteristically striated or ribbed longitudinally. The cells divide while quiescent into groups of four or eight (fig. 17) and these daughter cells when liberated soon achieve the size of the parent cells. The chloroplastid in my specimens was filled with abundant starch grains. The nucleus is located in the posterior third of the cell and lies within the opening of the chloroplastid. The shape of the chloroplastid and the central position of the pyrenoid indicate that the species belongs in the section *Pseudoagloë* Pascher. As far as I can ascertain this organism is reported here for the first time from the United States.

Carteria ellipsoidalis sp. nov.—Cellulis vere et semper ellipsoidalibus; chromatophora aperte urceolata; stigmate in media parte vel subanteriore chromatophorae; pyrenoide singula grande axiale; nucleo incluso in cytoplasmate sine colore; cellulis sine papilla; vacuolibus contractalibus praesentibus; longitudine cellulae vegetativae 6–24μ; ceteris characteribus similibus generi. Propagatio fit 2, 4 aut 8 cellulis intra cellulae matricalis mebranum ortis. Hab. In fossa juxta agrum campestrem, Solomons, Calvert Co., Maryland (figs. 18–20).

These organisms were repeatedly collected from barnyard puddles similar to those in which *Pyramimonas montana* occurred. The cells vary from 10 to 25 microns in length and are always truly ellipsoidal in shape. The chloroplastid is very clearly urn- or cup-shaped with the opening usually extending well back toward the posterior half of the cell. There is

[2] Apparently the original publication of this species is in Pascher (1927, p. 157), since it is not found in any of Korschikoff's papers that are available: the case is an example of Pascher's inconvenient habit of failing to indicate species which are described as new.

a single axial pyrenoid which lies near the base of the chloroplastid, the latter being filled with minute starch grains some of which surround the pyrenoid. The stigma is small and located within the anterior third of the chloroplastid. The four flagella are about equal in length to the cell body and are attached to a minute blepharoplast which lies very near the margin of the protoplast. The cell wall is thin and lacks a papilla, and the protoplast is slightly truncated in this region. Cell division is longitudinal and occurs while the cells are in a quiescent condition; four- and eight-celled stages are commonly found (fig. 20). This organism is closely related to *C. globosa* Korsch. from which it differs plainly, however, in its pronounced and constant ellipsoidal form and in the smaller size of its cells. The present species like *C. globosa* belongs to the section EUCARTERIA.

CHLAMYDOMONAS METASTIGMA (Stein) Gorosch. (fig. 21).—This organism occurred sparingly in barnyard puddles along with the above species of *Carteria*. It belongs to the sub-genus *Amphichloris* Pascher, and is characterized by the presence of both anterior and posterior pyrenoids which are embedded axially in the urn-shaped chloroplastid. The latter is partially perforated near the equator of the ellipsoidal cell and the stigma is posterior to this opening. The nucleus lies in the central portion of the cell and is often visible through the opening in the chloroplastid. The latter is like a window and does not completely divide the chloroplastid. In my specimens vegetative cells vary in length from 11.8 to 16 microns the cells being slightly smaller than those observed by Goroschankin (1891). The cells lack a papilla; no stages in reproduction were observed.

Chlamydomonas schizochlora sp. nov. (figs. 13–15).—Cellulis vegetativis grandibus, 30–40μ longitudine, cylindroidibus; anteriore papilla obtusa; chromatophora fissa in multas partes sed in toto urceolata; una pyrenoide in quoque segmente; stigmate lanceolato usque ad 5μ flagellis brevibus, minoribus quam dimidio longitudinis cellulae; nucleo subanteriore, sphaerico; vacuolibus contractalibus praesentibus. Propagatio non observata est. Hab.: In stagno, Solomons, Calvert Co., Md.

This organism was observed infrequently sparingly mixed with other algae in a small pond or swamp at Point Patience, Calvert County, Md., and is clearly a member of the sub-genus *Pleiochloris* Pascher in which the cells contain many laterally distributed pyrenoids. The cells are elongated, cylindrical-ellipsoidal and relatively large varying from 31–40 microns in length and are somewhat less than half as wide. The posterior and anterior poles are equally rounded. The chloroplastid as a whole is cup- or urn-shape, but is incompletely divided into mosaic-like segments each of which contains a single pyrenoid superficially embedded. The number of chloroplastid segments fluctuate in my specimens between eleven and seventeen.

The stigma is anterior, in edge view pointed at both ends, in face view narrowly elliptical, and may reach a length of 5 microns. Two contractile vacuoles are present beneath the lenticular papilla and below them in the colorless cytoplasm a rather large nucleus is present (figs. 13–15). The two flagella are short, less than one half the length of the cell body and they emerge close together through the broad papilla. The cells I observed were extremely sluggish in their movements, perhaps because of the large size of the cells in relation to the size of the flagella. This organism is closely related to *C. breviciliata* Korsch. from which it is readily distinguishable however by the mosaic chloroplastid and by the anterior position of the extremely elongated stigma and by the more anterior position of the nucleus.

PHACOTACEAE

DYSMORPHOCOCCUS VARIABILIS Takeda (figs. 22–25).—This organism appeared in great numbers in barnyard puddles along with other Volvocales during the summer of 1936. The genus was described by Takeda (1916) from material collected in a small pool in Surrey, England; Korschikoff (1925) reports the occurrence of *D. variabilis* Takeda and a new species *D. coccifera* in the vicinity of Charkow. As is typical of members of this family, the cells of *Dysmorphococcus* are encased within a lorica which is almost colorless in young individuals but becomes dark brown in more mature cells. The surface of the lorica appears rough under low magnifications but higher magnification reveals the presence of a pattern or sculpturing on the lorica. Takeda reported that this consisted of closely placed granules: "It can be positively stated," he says, "that they are granules, and not scrobiculations." Korschikoff on the contrary reports that the shell in the same species is ornamented not with granules but with true pores which in transverse section, as seen at the surface, appear to be hexagonal. I can substantiate the observations of Korschikoff on this point though there seems to be a high frequency of occurrence of pentagons and other types of polygons in cross sectional views of the pores. An accurate picture of the pores is only obtained through the use of an apochromatic optical system. Under lower magnifications the shell does not appear granulated and I have represented it in this manner in figure 25, below which I have depicted a more detailed segment of a shell. Takeda mentions the occurrence of a "dotted line" running longitudinally around the shell; critical observation convinces me that this is always present and that it consists in reality of a narrow band of wall material in which no pores occur (fig. 23) and along which the splitting of the shell occurs at the time of reproduction. Korschikoff (1925) comes to a similar conclusion in

his studies of *D. coccifera*. The size of the shells which I have observed falls within the specific limits given by Takeda, namely 14–19 microns long and between 13 and 17 microns broad across the flattened surface. The lorica displays a pronounced dorsiventrality, being somewhat flattened in a plane at right angles to the long axis especially posteriorly (fig. 23); it is more rounded usually anteriorly (fig. 24). The flagella of the contained protoplast emerge through two minute openings which are oriented at about 45° angles with reference to a plane parallel to the broad surface of the shell. The protoplast is always smaller than the lorica and is pear-shaped with the colorless beak being attached near the apex of the shell. Along with Takeda and Korschikoff I have been unable to convince myself that the protoplast is walled. Its structure is typically Volvocine: contractile vacuoles, stigma, a single pyrenoid and urn-shaped chloroplastid, and nucleus are present. The protoplast of the cell figured as 22 contains two pyrenoids and two stigmas which indicates apparently that nuclear and cytoplasmic division are soon to follow. Unfortunately I was unable to observe division stages. Korschikoff (1925) describes reproduction as consisting of the division of the protoplast into two motile individuals which escape by the fission of the parent shell and secrete new shells for themselves.

SPONDYLOMORACEAE

CHLAMYDOBOTRYS STELLATA Korsch. (fig. 26).—As Smith (1933) points out, considerable confusion exists with reference to the occurrence of members of *Chlamydobotrys* in the United States, since they have sometimes been confused with *Spondylomorum quaternarium* which regularly has cells with four flagella. The figure of *Chlamydobotrys gracilis* reproduced as 232 by Smith (1933) and copied from an unpublished drawing of Professor Hazen, is based on material collected near London, England, so that there are, so far as I am aware, no published records of occurrence of the genus *Chlamydobotrys* in the United States except Mast's (1918) report of a *biflagellated "Spondylomorum quaternarium."* In a preliminary contribution (Bold, 1933) I reported finding *C. gracilis* Korsch. in barnyard puddles in Maryland. Subsequent observations convince me that the organism is really *C. stellata* Korsch., since it regularly occurs in the eight-celled condition and the stigmas tend to be anterior or equatorial rather than posterior. In addition the cell wall is drawn out into a distinct process posteriorly, which is typical of *C. stellata*. The cells in my specimens were about 15.4 microns in length and approximately half that width at the widest point (fig. 26).

Explanation of Plates 6 and 7

All figures were drawn with a camera lucida and 1.9 mm. oil immersion objective, N.A. 1.30, and a 10× compensating ocular. Figure 11 is from a stained preparation; all other figures are from living cells. The drawings are reproduced without reduction and the magnifications are as follows: Figs. 1–10 and 12 are drawn with a magnification of 1200×; Figure 11 approximately 1425×; figures 13–26 1500×.

Plate 6

Pyramimonas montana Geitler

Fig. 1. Vegetative individual in surface view.
Fig. 2. Vegetative individual in median optical section.
Fig. 3. Anterior view of a vegetative individual.
Fig. 4. An encysted individual.
Figs. 5–10 and 12. Stages in asexual reproduction.
Fig. 11. Cell fixed in corrosive sublimate and stained in Haidenhain's haematoxylin.

Chlamydomonas schizochlora Bold

Fig. 13. Vegetative individual with stigma in surface view.
Fig. 14. Vegetative individual in anterior view.
Fig. 15. Vegetative individual rotated about 90°, stigma in edge view.

Plate 7

Carteria crucifera Korsch

Fig. 16. Vegetative individual.
Fig. 17. Four daughter cells.

Carteria ellipsoidalis Bold

Fig. 18. Vegetative individual in median optical section; surface view of pyrenoid.
Fig. 19. Anterior aspect of vegetative individual.
Fig. 20. Eight daughter cells.

Chlamydomonas metastigma (Stein) Gorosch

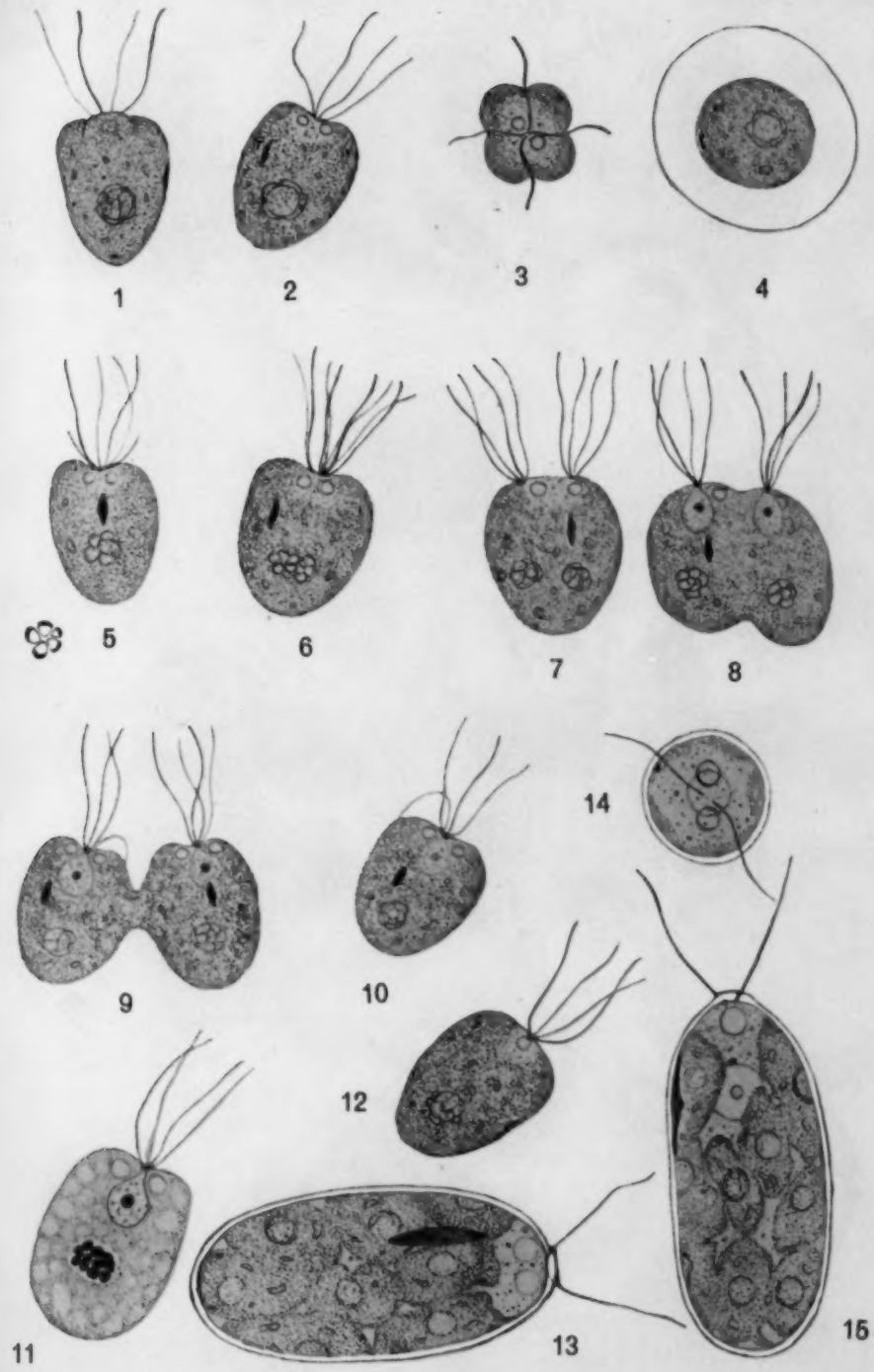
Fig. 21. Vegetative individual.

Dysmorphococcus variabilis Takeda

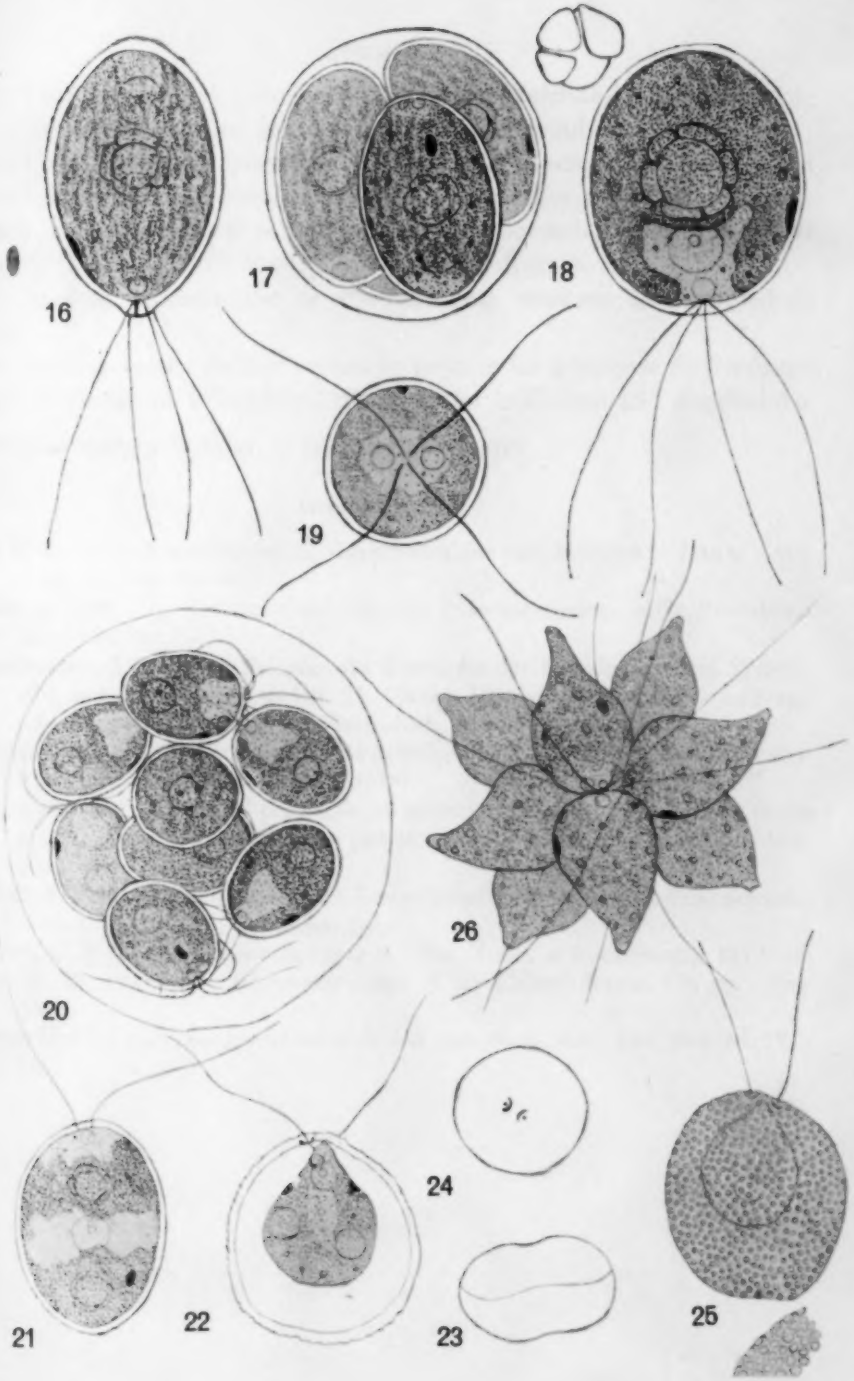
Fig. 22. Vegetative individual preparing for division, median optical section.
Fig. 23. Posterior view of lorica.
Fig. 24. Anterior view of lorica showing flagellar apertures.
Fig. 25. Surface view of a vegetative individual; detail of shell structure.

Chlamydobotrys stellata Korsch.

Fig. 26. Vegetative colony.



BOLD, MARYLAND ALGAE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SUMMARY

1. Two new species, namely *Carteria ellipsoidalis* and *Chlamydomonas schizochlora* are described and figured from Maryland.

2. Five species are reported for the first time as occurring in the United States. They are: *Pyramimonas montana* Geitler, *Carteria crucifera* Korsch., *Chlamydomonas metastigma* (Stein) Gorosch., *Dysmorphococcus variabilis* Takeda, and *Chlamydobotrys stellata* Korsch.

3. Asexual reproduction of *Pyramimonas montana* is described in detail.

In conclusion the author wishes to express his gratitude to Professor Tracy E. Hazen of Columbia University for criticisms and suggestions.

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Pteridophyta of the Galapagos and Cocos Islands[1]

H. K. Svenson
(with plates 8 to 10)

The basis for the materials of this paper is the collection made by the Astor Expedition to these islands in 1930 (specimens in herb. Brooklyn Botanic Garden), the phanerogams of which have already been reported upon.[2] Through the kindness of Mr. John S. L. Gilmour, now assistant director of the Royal Botanic Gardens at Kew, arrangements were made in 1933 to examine Darwin's specimens collected on the memorable voyage of the *Beagle*, now incorporated in the general herbarium of the University of Cambridge, and representing the first record of ferns from the Galapagos Islands. All of these were found with the exception of the unimportant *Asplenium subulatum*. In addition, through the kindness of Mr. Gilmour and with the help of Mr. Ballard, the collections of Captain Wood and Captain Markham, cited by Moore in *Index Filicum* and by Sir W. J. Hooker in *Species Filicum* were examined at Kew. Since genera and species have been much altered in the past century, a considerable amount of search was often necessary in locating these old specimens, but nearly all of any great interest were uncovered.

Mr. C. A. Weatherby, Senior Curator of the Gray Herbarium, has given me kindly assistance throughout my investigations. To Dr. W. R. Maxon, of the United States National Herbarium, I have been much indebted for determination of difficult species, for good advice, and for correction of occasional determinations; and to Mr. C. V. Morton of the same institution I am also indebted for help. Dr. H. A. Gleason of the New York Botanical Garden has been most kind in lending specimens from the large South American collections at that institution. Mr. John Thomas Howell of the California Academy of Sciences has most generously given me duplicates from Stewart's collection from the Galapagos Islands, and has lent me many of Stewart's critical specimens not represented in other herbaria. The abbreviations for herbaria used in the citation of specimens, I believe, are obvious.

While every effort has been made to include all important records of pteridophytes from the Galapagos Islands, thereby providing a survey of the pteridophyte flora, no such attempt is just at present being made for the ferns of Cocos Island. Despite extensive exploration, some of the ferns of Captain Wood's collection have never since been noted from the

[1] Brooklyn Botanic Garden Contributions. No. 83.

[2] Am. Journ. Bot. **22**: 208–277 (1935).

Galapagos Islands, and I strongly suspect that such specimens were obtained elsewhere, probably on the continent of South America. They were undoubtedly erroneously ascribed to the Galapagos Islands through mixture of localities after the tragic death of Edmonston,[3] the botanist accompanying the *Pandora* (Commander, Captain Wood), which explored the Galapagos Islands in company with the *Herald*. According to Dr. Robinson (p. 221), 44 ferns were received at Kew in 1854, and the identifications by Sir W. J. Hooker were noted in scattered citations throughout *Species Filicum*. The specimens which I suspect were collected elsewhere than in the Galapagos Islands are as follows:

Adiantum Alarconianum
" *patens*
" *tetraphyllum*
Ananthocorus angustifolius
Asplenium laetum
" *rutaceum*
" *serratum*
Cyclopeltis semicordata
Dryopteris glandulosa var. *brachyodus*
" *rudis*
Histiopteris incisa
Polypodium loriceum
" *percussum*
Pteris propinqua var. *Cumingiana*

With elimination of these species, the relationships of the pteridophyte flora of the Galapagos Islands may be discussed. Since they are desert islands with moist conditions only on the windward uplands, the number of species (66) is comparatively meagre. Of the three recognized endemics, *Asplenium carolinum* is scarcely more than a form of the widespread *A. formosum*. The second, *Polypodium pleiosorus* of Darwin's collection (now to be placed in *Dryopteris*), inhabits the moist summits of James and Chatham Islands, and is close to the polymorphic West Indian and Andean *D. subincisa*. *Notholaena galapagensis*, to be described in this paper, a species of dry rocks and a relative of the Mexican *N. candida*, is perhaps the same as one or two nondescript Peruvian or Chilian collections.

Several species are of restricted range. *Polypodium tridens*, long passing under *P. squamatum*, is found also on the adjacent coast of Ecuador. *Asplenium poloense*, described from the Bolivian Andes and belonging to the difficult *lunulatum*-group, is probably more widespread than available collections indicate. Undoubtedly the most spectacular of Galapagos ferns is *Trachypteris pinnata*, a "resurrection" fern not uncommon on rocky banks, and a member of a genus with only three known species: the Galapagos plant, an inhabitant also of the Bolivian and Peruvian Andes; *T. Gillianum* from eastern Brazil and adjacent Argentina; and *T. Drake-*

[3] Thomas Edmonston (1825–1846), a native of the Shetland Islands, was killed by accidental gunshot on boarding a boat in the surf at Sua near Atacamas on the Ecuadorean mainland (cf. The Phytologist **2**: 580 (1846)).

ana, only recently described by Christensen[4] from Madagascar. The remainder of the species, except for a tree-fern (*Hemitelia* aff. *subcaerulea*), a member of a group notorious for its restricted and isolated species, appear to be wide-ranging.

The following pteridophytes (40) are common to the Galapagos Islands and the West Indies:[5]

Acrostichum aureum
Adiantum concinnum
" *macrophyllum*
" *petiolatum*
" *villosum*
Asplenium auritum
" *cristatum*
" *formosum* (*A. carolinum*)
" *myriophyllum*
" *pumilum*
" *Serra*
Blechnum occidentale
" *unilaterale*
Cheilanthes microphylla
Doryopteris pedata
Dryopteris gongylodes
" *patens*
" *Poiteana*
" *tetragona*
Elaphoglossum petiolatum
Hymenophyllum ciliatum
Hypolepis repens
Nephrolepis biserrata
Pityrogramma calomelanos
Polypodium angustifolium
" *aureum*
" *crassifolium*
" *lanceolatum*
" *pectinatum*
" *Phyllitidis*
" *polypodioides*
Polystichum adiantiforme
Pteris biaurita (*P. quadriaurita*)
Tectaria martinicensis
Trichomanes Krausii
Lycopodium cernuum
" *dichotomum*
" *reflexum*
" *taxifolium*
Psilotum nudum

Cocos Island (off the coast of Costa Rica) and the Galapagos Islands have a number of pteridophytes in common. Though only three miles in diameter, Cocos has a high proportion of ferns (22 species were collected by the Astor Expedition), due to the heavy covering of tropical rain forest. The following species (8) are found on both the Galapagos and Cocos Islands.

Acrostichum aureum
Adiantum petiolatum
Nephrolepis biserrata
" *pectinata*
Pityrogramma calomelanos
Polypodium aureum
" *Phyllitidis*
Polystichum adiantiforme

Several widely distributed tropical pteridophytes (19) are known from the Galapagos Islands and Madagascar (cf. Christensen, l.c.):

[4] Dansk Bot. Arkiv **7**: 111. t. 42 (1932).

[5] Cf. Domin, The Pteridophyta of Dominica, Roy. Czech. Soc. Nat. Hist. Mém. n. ser. no. 2 (1929); Maxon, Surv. Porto Rico and Virgin Ids. **6**: 373–521 (1926).

Acrostichum aureum
Anogramma leptophylla
Asplenium auritum
" *formosum* (*A. carolinum*)
" *praemorsum*
Dryopteris gongylodes
" *mollis*
Elaphoglossum petiolatum
Gleichenia linearis
Hymenophyllum ciliatum
Nephrolepis biserrata
Pityrogramma calomelanos
Polypodium lanceolatum
Polystichum adiantiforme
Pteris quadriaurita (*P. biaurita*)
Lycopodium cernuum
" *clavatum*
" *complanatum*
Psilotum nudum

In the Galapagos Archipelago, the distribution of ferns is probably much the same on all the larger islands. As is the case with the flowering plants of Indefatigable Island,[6] different species of ferns are progressively seen as one ascends the moist mountain slopes from the desert areas of the coast, and a similar progression probably occurs on the windward side of all the larger islands. At Academy Bay, on the south (and moist) side of Indefatigable Island the first fern to be encountered is *Notholaena galapagensis*, which is abundant on the escarpment at about 100 ft. elevation. Exposed lava banks soon reveal the rosettes of *Trachypteris pinnata*, a species which reaches its maximum development on rocks and logs in the damper woodlands. At about 500 ft. *Asplenium auritum* and *Polypodium lepidopteris* cluster on tree trunks with *Tillandsia insularis* and the orchid, *Ionopsis utricularioides*. At this elevation, by brushing aside grasses and shrubbery, one can readily disclose *Doryopteris pedata*, *Asplenium carolinum*, and *Polypodium tridens* beneath the shade of jagged lava fragments. When the densest vegetation is reached, at about 800 ft., bird's-nest ferns (*Polypodium Phyllitidis*) and maidenhair ferns (*Adiantum Henslovianum*) are not uncommon in the underbrush. A little higher, in the cleared areas of the plantation *Fortuna*, a strong growth of *Hypolepis repens* and occasional plants of *Adiantum villosum* are encountered, perhaps owing their presence to human habitations. On the steep mountain slope above the plantation, overhanging boulders provide shaded spots suitable for the growth of *Adiantum macrophyllum*, and for the yellow-powdered fronds of *Gymnogramme tartarea*. Toward the summit, at an altitude of about 2,000 ft.—the highest point our party was able to reach—the dwarfed trees are festooned with liverworts and epiphytic lycopodiums, on the ground there are banks of *Blechnum unilaterale* and *Nephrolepis pectinata*, and in openings tall brakes of *Pteridium arachnoideum* are not uncommon.

[6] Cf. Tabular view of Altitudinal Distribution, Am. Journ. Bot. **22**: 210–211 (1935).

Bibliographical references occurring frequently in the text are abbreviated as follows:

Rob. (1). Robinson, B. L. Flora of the Galapagos Islands. Proc. Amer. Acad. **38**: 77–269, 3 pl. (1902).

Stewart (1). Stewart, A. A botanical survey of the Galapagos Islands. Proc. California Acad., ser. 4, **1**: 7–288, 19 pl. (1911).

Stewart (2). Stewart, A. Notes on the botany of Cocos Island. Proc. California Acad., ser. 4, **1**: 375–404, 4 pl. (1912).

The collections by Rorud were cited in E. Christophersen, Nyt. Mag. for Naturvidenskaberne **70**: 69–70 (1932), and were determined by Dr. Christensen. Moore's references to Galapagos ferns and early citations by Andersson, Caruel, etc. will be found in Dr. Robinson's account.

FILICES[7]

ACROSTICHUM L.

A. AUREUM L. Sp. Pl. 1069 (1753); Rob. (1), 104; Stewart (1), 11.—ALBEMARLE ISL.: Villamil, 3150 ft., *Stewart*. GALAPAGOS IDS.: *Capt. Wood*, two sheets of rather young material.

ADIANTUM L.

*A. ALARCONIANUM Gaud. Voy. Bon. Bot. t. 99 (1846); Stewart (1), 11. *A. incisum* Presl; Rob. (1), 105.—GALAPAGOS IDS.: *Capt. Wood*, two sheets of branched specimens (as *A. incisum* Presl).

A. CONCINNUM H. & B. in Willd. Sp. **5**: 451 (1810); Rob. (1), 105; Stewart (1), 11. *A. cuneatum* sensu Hook.f. Trans. Linn. Soc. **20**: 168 (1847), not Langsd. & Fisch. *A. aethiopicum* sensu Moore, Ind. Fil. **19**: (1857), not L.; Rob. (1), 105; Stewart (1), 11.—ABINGDON ISL.: *Snodgrass & Heller; Stewart*. ALBEMARLE ISL.: *Snodgrass & Heller; Stewart*. CHARLES ISL.: *Stewart*. INDEFATIGABLE ISL.: *Rorud*. JAMES ISL.: *Darwin; Scouler; Snodgrass & Heller*. NARBOROUGH ISL.: *Snodgrass & Heller* (?). GALAPAGOS IDS.: *Douglas* (Kew).

Darwin's collection is typical *A. concinnum*. The specimen of *A. aethiopicum*, collected by Douglas, and evidently the basis of Moore's citation, is without question a small, poor specimen of the same species. It has a perfectly smooth rachis and a few very old sori.

A. HENSLOVIANUM Hook.f. Trans. Linn. Soc. **20**: 169 (1847); Rob. (1), 105; Stewart (1), 11. *A. parvulum* Hook.f. Trans. Linn. Soc. **20**: 168 (1847). *A. diaphanum* sensu Stewart (1), 11; not Bl.—ABINGDON ISL.: *Stewart*. ALBEMARLE ISL.: *Stewart*, including no. 785 (Cal) (as *A. diaphanum*).

[7] Species marked by an asterisk (*) are probably not from the Galapagos Islands Previous inclusion in the flora is probably due to Edmonston's confused data. (See introduction, p. 304.)

CHARLES ISL.: *Darwin* (4 specimens). CHATHAM ISL.: *Baur; Stewart* no. 784 (US) (as *A. concinnum*). INDEFATIGABLE ISL.: *Stewart;* Academy Bay, wet shady places among rocks, 1100–1500 ft., *Svenson* no. 144. JAMES ISL.: *Darwin; Stewart.*

Darwin's specimen of *Adiantum parvulum* (from Charles Island) is a very small example with pinnules not exceeding 10 mm. × 4 mm. and none have more than one or two sori. The shiny, almost black stipe has somewhat clavate scurf, exactly as in *A. Henslovianum.* The material reported by Stewart as *Adiantum diaphanum* is very young but shows under microscopic examination the indusia characteristic of *A. Henslovianum,* and the same type of scurfy rachis.

A. MACROPHYLLUM Sw. Prod. 135 (1788); Stewart (1), 12.—ALBEMARLE ISL.: *Stewart.* INDEFATIGABLE ISL.: *Stewart; Rorud.* JAMES ISL.: *Stewart.* Young fronds of this species, of a translucent, pinkish color, were noted but not collected, beneath damp boulders at about 1,000 ft. elevation at Academy Bay.

*A. PATENS Willd. Sp. **5:** 439 (1810); *Stewart* (1), 12.—GALAPAGOS IDS.: *Capt. Wood.* The specimen which I saw at Kew is identical with *Schlim* no. 616 from Ocaña, New Granada, and very close to *Seeman* no. 1448 from Mexico.

A. PETIOLATUM Desv. Berl. Mag. **5:** 326 (1811); *Stewart* (1), 12. *A. Kaulfussii* Kunze, Linnaea **21:** 221 (1848); Rob. (1), 105.—CHATHAM ISL.: *Capt. Wood* (Kew), a specimen of apparently typical material.

*A. TETRAPHYLLUM H. & B. in Willd. Sp. **5:** 441 (1810); *Stewart* (1), 12. *A. prionophyllum* HBK Nov. Gen. & Sp. **1:** 20 (1815); Rob. (1) 106.—CHATHAM ISL.: *Capt. Wood,* two sheets identical with *Lehmann* no. 7685.

A. VILLOSUM L. Syst. Nat. ed. 10, **2:** 1328 (1759).—INDEFATIGABLE ISL.: Academy Bay, in cut-over places in vicinity of the Plantation Fortuna, 800 ft., *Svenson* no. 101; Academy Bay, 500 ft., *Stewart* no. 798 (G) (as *E. petiolatum*). My collection is in excellent agreement with Schkuhr's plate.

ANOGRAMMA Link

A. CHAEROPHYLLA (Desv.) Link, Fil. Sp. 138; (1841) *Stewart* (1), 12. *Gymnogramma chaerophylla* Desv. Berl. Mag. **5:** 305 (1811); Rob. (1), 109.—CHARLES ISL.: *Darwin,* the specimen is in good condition and unquestionably *A. chaerophylla.*

A. LEPTOPHYLLA (L.) Link, Fil. Sp. 137 (1841); Stewart (1), 12. *Gymnogramma leptophylla* Desv. Berl. Mag. **5:** 305 (1811); Rob. (1), 109.—CHARLES ISL.: *Baur.*

Ananthocorus Underw. & Maxon

*A. angustifolius (Sw.) Underw. & Maxon, Contr. U. S. Nat. Herb. **10:** 487 (1908). *Vittaria angustifolia* (Sw.) Bak. Fl. Bras. **1**[2]**:** 544 (1870); Stewart (1), 27. *Pteris angustifolia* Sw. Prod. 129 (1788). *Taenitis angustifolia* Spr. Syst. **4:** 42 (1827); Hook. Sp. Fil. **5:** 187 (1864); Rob. (1), 115.—Galapagos Ids.: *Capt. Wood*, the specimen (cited by Hooker) has fronds 3 dm. long, and as much as 8 mm. wide.

Asplenium L.

A. auritum Sw. in Schrad. Journ. **1800**[2]**:** 52 (1801); C. Chr. Archiv. f. Bot. **9**[11]**:** 16, t. 1, fig. 1 (1910); Rob. (1), 106; Maxon, Bot. Porto Rico & Virgin Ids. **6:** 450 (1926); Domin, Pterid. Dominica 176 (1929). *A. sulcatum* Lam. Encyc. **2:** 308 (1786); Stewart (1), 15. *A. marinum* var. *auriculatum* Hook.f. Trans. Linn. Soc. **20:** 170 (1847). *A. auritum* var. *macilentum* Moore, Ind. Fil. 115 (1859); Rob. (1), 107. *A. lunulatum* sensu Rob. (1) 107; not Sw.—Abingdon Isl.: *Snodgrass & Heller; Stewart.* Albemarle Isl.: *Stewart.* Charles Isl.: *Darwin; Andersson; Agassiz; Stewart.* Chatham Isl.: *Capt. Wood; Stewart.* Indefatigable Isl.: *Stewart; Svenson.* James Isl.: *Darwin; Stewart; Rorud* (var. *macilentum*).

Much variation is shown in Captain Wood's collection at Kew. One of his specimens (Chatham Isl.) with somewhat dissected pinnae and the accompanying query "rigidum?" strongly resembles Stewart's no. 812 (James Isl.) but is far removed from *A. rigidum* as illustrated by Christensen (l.c.). The third collection, labeled merely "Galapagos Islands," is a small var. *macilentum* with small obtuse pinnae and no trace of auricles.

Domin (l.c.) notes that var. *macilentum* is abundant in Jamaica at an altitude of from 5,000 to 6,000 ft. on exposed rocks. From personal observation I cannot see that the variations displayed in the Galapagos Islands are significant from the point of view of geographical distribution. Of the three collections of this abundant epiphyte which I made on Indefatigable Island, no. 53 (500 ft. altitude) verges toward var. *macilentum;* no. 100 (700 ft.) is nearer the type; and no. 97 (2,000 ft.) is var. *macilentum.* The specimens cited by Christophersen, determined by Christensen as "var. *macilentum*" came two kilometers from the shore, on James Island. None of the specimens which I have seen are characterized by a "*rachis* broadly winged," stated by Hooker & Baker (Syn. Fil. 208 (1873)) as one of the characteristics of *A. macilentum.*

Lee's specimens of *A. lunulatum* (U. S. Nat. Herb.) are, according to a communication from Dr. Maxon, representative specimens of *A. auritum.* Darwin's collections are of the typical form.

A. FORMOSUM Willd. Sp. **5:** 329 (1810); Rob. (1), 107; Stewart (1), 13. *A. carolinum* Maxon, Contr. U. S. Nat. Herb. **17:** 148 (1913). *A. subalatum* Hook. & Arn. Bot. Beech. Voy. 312, t. 71 (1840); Hook.f. Trans. Linn. Soc. **20:** 169 (1847) (as *A. subulatum*); Andersson, [Eugenies Resa, Bot.] Kgl. Sv. Vet. Akad. Handl. **1853:** 131 (1854) and **1857:** 41 (1861).—ABINGDON ISL.: *Snodgrass & Heller; Stewart.* ALBEMARLE ISL.: *Snodgrass & Heller; Stewart.* CHARLES ISL.: *Darwin; Capt. Markham* (Kew), labeled "11–80"; *Lee; Baur; Stewart.* CHATHAM ISL.: *Capt. Wood; Cuming* (Kew); *Stewart.* INDEFATIGABLE ISL.: *Stewart; Rorud;* Academy Bay, common in leaf mould in rocky woods, 500 ft., *Svenson* no. 75. JAMES ISL.: *Stewart.* NARBOROUGH ISL.: *Stewart.*

"*Asplenium subulatum*" Hook.f. was the only specimen of the Darwin collection which I was unable to find at Cambridge.

A. CRISTATUM Lam. Encyc. **2:** 310 (1786); Stewart (1), 13. *A. cicutarium* Sw. Prod. 130 (1788). *A. rhizophyllum* sensu Rob. (1), 107, not Kunze. *A. Macraei* sensu Hook.f. Trans. Linn. Soc. **20:** 169 (1847), not Hook. & Grev. *A. myriophyllum* sensu Stewart (1), 14, not (Sw.) Presl.—ABINGDON ISL.: *Stewart.* ALBEMARLE ISL.: *Stewart.* CHATHAM ISL.: *Capt. Wood; Baur; Stewart.* INDEFATIGABLE ISL.: *Stewart; Rorud;* Academy Bay, common among rocks in shade of shrubs and vines, 800 ft., *Svenson* no. 108. JAMES ISL.: *Darwin; Stewart.*

Identity of the Galapagos plants has been greatly confused due to merging of the perfectly distinct *A. Macraei* of the Hawaiian Islands and Cocos Island with *A. rhizophyllum*, and confusion of *A. cristatum* (*A. cicutarium*) of the Galapagos Islands with *A. rhizophyllum*.

Two specimens of *A. cristatum* at Kew were collected on Chatham Island by Captain Wood. One of these is labeled *A. rhizophyllum*, (a distorted specimen partially covered with liverworts and mounted with *Jameson* no. 28 from Quito); the other is labeled *A. Macraei* and mounted on a sheet of that species. Darwin's collection at Cambridge (consisting of two sheets labeled *A. Macraei*) is also *A. cristatum*. These collections of Darwin and Capt. Wood are the only basis for Stewart's citation of *A. myriophyllum*.

*A. LAETUM Sw. Syn. Fil. 79, 271 (1806); Rob. (1), 107; Stewart (1), 14.—CHATHAM ISL.: *Capt. Wood.* This specimen, the only record for the Galapagos Islands, has pinnae 2.5–3 cm. long and 0.8–1.0 cm. broad, the margin sharply but somewhat irregularly serrate. The species is abundant in the West Indies (cf. Domin, Pter. Dominica 174, (1929)), and in continental America extends from Mexico to Southern Brazil.

A. MYRIOPHYLLUM (Sw.) Presl, Rel. Haenk. **1:** 48 (1825).—INDEFATIGABLE ISL.: In the forest, the moist region, 255–300 m., *Rorud* no. 254.

(Specimen (det. Christensen) examined through the kindness of Dr. Erling Christophersen).

A. POLOENSE Rosenst. in Fedde, Rep. Spec. Nov. **12:** 469 (1913).—INDEFATIGABLE ISL.: Academy Bay, south slope of the mountain on vertical damp ledges in stream bed, 1000–5000 ft., *Svenson* no. 130. The rachis is slightly channeled and compressed-sulcate at base; the shiny subulate scales are deep brown with clearly-defined reticulation at the apex. *A. poloense* is a Bolivian species known previously only from Buchtien's no. 3345, collected in "Yungas septentrionalis, Polo-Polo prope Coroico, 900 m. alt." It is said to be related to *A. pulcherrima* Raddi (?*A. pulchellum*) and in its strongly auriculate and deeply incised pinnae it approaches *A. Fernandezianum* Kze.

A. PRAEMORSUM Sw. Prod. 130 (1788); Stewart (1), 14. *A. furcatum* Thunb. Prod. Fl. Cap. 172 (1800); Hook.f. Trans. Linn. Soc. **20:** 169 (1847); Rob. (1), 107.—ALBERMARLE ISL.: *Snodgrass & Heller; Stewart.* JAMES ISL.: *Darwin; Stewart.* NARBOROUGH ISL.: *Stewart.* INDEFATIGABLE ISL.: *Stewart;* Academy Bay, a common epiphyte at 1,400–1,500 ft. *Svenson* no. 128, and 2,000 ft. (no. 211). I did not see Capt. Wood's collection cited by Hooker, Sp. Fil. **3:** 167 (1860). A species of wide tropical distribution.

A. PUMILUM Sw. Prod. 129 (1788); Stewart (1), 14.—CHARLES ISL.: *Stewart.* INDEFATIGABLE ISL.: *Stewart.* Stewart's collections closely resemble Small's illustration in Ferns of Florida: 133 (1931).

*A. RUTACEUM (Willd.) Metten. Abh. Senck. Nat. Gesell. Frankfurt **3:** 129, t. 5, fig. 32–33 (1859); Rob. (1), 108; Stewart (1), 14.—CHATHAM ISL.: *Capt. Wood.* The specimen is identical with *Moritz* no. 402 from Tovar Colombia (K).

A. SANGUINOLENTUM Kunze ex Mett. Abh. Senck. Nat. Gesell. Frankfurt **3:** 142, t. 4, fig. 10 (1859). *A. nigrescens* Hook.f. Trans. Linn. Soc. **20:** 170 (1847), not Blume (1828). *A. nubilum* Moore[8] Ind. Fil. 150 (1859). *A. anisophyllum* var. *latifolium* Hook.f., Sp. Fil. **3:** 111 (1860); Rob. (1), 106; Stewart (1), 13. *A. sarcodes* Maxon, Contr. U. S. Nat. Herb. **10:** 494, t. 56, fig. 3 (1908). *A. anisophyllum* var. *sanguinolentum* Hieron. Hedwigia **47:** 226 (1908).—ALBEMARLE ISL.: *Capt. Wood; Stewart* no. 857 (G), (as *A. Serra*). CHATHAM ISL.: *Stewart* no. 858 (G, Cal, NY) (as *A. Serra*). INDEFATIGABLE ISL.: Academy Bay, 1000–1600 ft., plants 3 ft. high with a prominent blackened base, *Svenson* nos. 125, 221. JAMES ISL.: *Darwin;* above 2000 ft., *Stewart* nos. 860 (Cal), 861 (Cal, G) (as *A. Serra*).

[8] Moore's name appeared in December, 1859. Maxon (l.c.) gives the year, 1860, for Mettenius' publication, but in a later treatment (Bot. Porto Rico & Virgin Isls. 6[3]: 449 (1926)), the date appears as 1859, which would undoubtedly be earlier than the issue of Moore's name.

The two sheets of Darwin's collection (upon which the name *A. nubilum* was based) are substantially the same as mine and identical with material from Cuba, and with Maxon's figure of *A. sarcodes*. The latter species has already been placed in synonymy under the wide-spread *A. sanguinolentum* by Christensen.

A. Serra* Langsd. & Fisch. Icon. Fil. **16, t. 19 (1810); Rob. (1), 108; Stewart (1), 15.—ALBEMARLE ISL.: *Stewart* nos. 856, 857 (Cal). DUNCAN ISL.: *Stewart* no. 859 (Cal). GALAPAGOS IDS.: *Capt. Wood;* no definite locality is given on the label.

A. SERRATUM L. Sp. Pl. 1079 (1753); Rob. (1), 108; Stewart (1), 15.—CHATHAM ISL.: *Capt. Wood*. The specimen at Kew is representative of this large bird's-nest fern.

BLECHNUM L.

B. OCCIDENTALE L. Sp. Pl. 1077 (1753); Rob. (1), 108; Stewart (1), 16.—ABINGDON ISL.: *Snodgrass & Heller; Stewart.* ALBERMARLE ISL.: *Snodgrass & Heller; Stewart.* CHARLES ISL.: *Andersson; Stewart.* CHATHAM ISL.: *Chierchia; Baur.* DUNCAN ISL.: *Stewart.* JAMES ISL.: *Darwin; Stewart.* Darwin's specimen is typical. Capt. Wood's collection, cited as var. *caudatum* by Hooker (Sp. Fil. **3:** 51 (1860)) consists of two specimens neither of which is labeled as the variety. One is a loose poorly-dried plant, with pinnae up to 10 cm. long and 12 mm. wide; the other has pinnae 2–3 cm. long, 5 mm. wide.

B. UNILATERALE Sw. Berl. Mag. **4:** 79, t. 3, fig. 1 (1810); Maxon, Bot. Porto Rico & Virgin Isl. **6**[3]**:** 456 (1926). *B. blechnoides* (Lag.) C. Chr. Ind. 151 (1905); Stewart (1), 15.—CHATHAM ISL.: Wreck Bay, 1700–2000 ft., *Stewart.* INDEFATIGABLE ISL.: Academy Bay, and epiphyte on the south slope of the mountain, alt. 2000 ft., *Svenson* no. 148, and not uncommon on the ground, alt. 2000 ft., *Svenson* no. 210.

CHEILANTHES Sw.

C. MICROPHYLLA Sw. Syn. 127 (1806); Rob. (1), 108; Stewart (1),16; Maxon, Contr. U. S. Nat. Herb. **24:** 52 (1922). *C. heterotricha* Andersson, [Eugenies Resa Bot.] Sv. Vet. Akad. Handl. **1853:** 129 (1854).—ABINGDON ISL.: *Stewart.* ALBEMARLE ISL.: *Snodgrass & Heller;* shady place near shore, *Stewart.* CHARLES ISL.: *Andersson; Stewart.* CHATHAM ISL.: *Baur.* INDEFATIGABLE ISL.: *Stewart;* Academy Bay, dry places along trails, 300 ft., *Svenson* no. 256. GALAPAGOS IDS.: *Capt. Wood* (Kew), a specimen labeled "Pellaea?", identical with *Stewart* no. 875 (Kew) from Albemarle Island.

C. MYRIOPHYLLA Desv. Berl. Mag. **5:** 328 (1811); Rob. (1), 109; Stewart (1), 17.—ALBEMARLE ISL.: *Snodgrass & Heller.*

CYCLOPELTIS J. Sm.

*C. SEMICORDATA (Sw.) J. Sm. in Curtis, Bot. Mag. **72:** Comp. 36 (1846); Stewart (1), 17. *Aspidium semicordatum* Sw.; Rob. (1), 106.—GALAPAGOS IDS.: *Capt. Wood* (Kew); two sheets.

DENNSTAEDTIA Bernh.

D. aff. GLOBULIFERA (Poir.) Hieron. in Engler, Bot. Jahrb. **34:** 455 (1904). *Polystichum apiifolium* sensu Stewart (1), 26; not (Sw.) C. Chr.—JAMES ISL.: occasional at 2000 ft. *Stewart* nos. 882, 883.

DICRANOPTERIS Bernh.

D. LINEARIS (Burm.) Underwood, Bull. Torrey Club **34:** 250 (1907). *Gleichenia linearis* (Burm.) Clarke, Trans. Linn. Soc. **2:** Bot. 1: 428 (1880); Stewart (1), 20. *G. dichotoma* Hook. Sp. Fil. **1:** 12 (1846); Rob. (1), 109.—CHATHAM ISL.: *Stewart.* DUNCAN ISL.: *Stewart.* GALAPAGOS IDS.: *Capt. Wood.* This collection, probably representing the citation by Moore (Ind. Fil. 376 (1862)), is the same as Stewart's collections, but a larger specimen. The exact identity of this material is uncertain.

DIPLAZIUM Sw.

D. aff. SUBOBTUSUM Rosenstock in Fedde, Rep. Spec. Nov. **7:** 296 (1909).—INDEFATIGABLE ISL.: Academy Bay, plants 4–5 ft. high, alt. 1625 ft., south slope of the mountain (*Svenson* no. 132) (Pl. 9, fig. 3). The segments are less acute than in *D. subobtusum*, which was described from a collection by Spruce (no. 4019) from Mt. Guayrapurina, Ecuador. It is related to *D. obtusum* Desv.

DORYOPTERIS J. Sm.

D. PEDATA (L.) Fée, Gen. Fil. 133 (1852); Stewart (1), 18. *Pteris pedata* L. Sp. Pl. 1075 (1753); Rob. (1), 114. *Litobrochia pedata* Presl; Hook. f. Trans. Linn. Soc. **20:** 168 (1847).—ABINGDON ISL.: *Stewart.* ALBEMARLE ISL.: *Snodgrass & Heller; Stewart.* CHARLES ISL.: *Darwin; Andersson; Capt. Markham; Lee; Baur; Stewart.* CHATHAM ISL.: *Baur; Stewart.* INDEFATIGABLE ISL.: *Stewart; Rorud;* Academy Bay, abundant in damp places among rocks, alt. 400 ft., *Svenson* no. 69. JAMES ISL.: *Darwin; Douglas; Cuming; Stewart.*

The collection by Darwin from James Island represents young material without sori; that from Charles Island is mature. I have also seen the specimens obtained by Capt. Wood, Cuming, and Capt. Markham, but was unable to locate any specimen of *Doryopteris concolor* (*Pellaea ge-*

raniaefolia) cited by Hooker, Sp. Fil. **2:** 133 (1858), nor did I find either at Cambridge or Kew any collection of *D. pedata* by Douglas. Since *D. concolor* (coll. *Douglas*) has never reappeared in any collection from the Galapagos Islands, it is probable that the specimen was confused with the similar *D. pedata*, or came from some other locality.

Dryopteris Adans.

D. AMPLA (Willd.) O. Ktze. Rev. Gen. Pl. **2:** 812 (1891); C. Chr. Vid. Selsk. Skr. ser. 8, **6**[1]**:** 49, fig. 9 (1920). *Polypodium paleaceum* Hook.f. Trans. Linn. Soc. **20:** 166 (1847); Andersson, [Eugenies Resa Bot.] Sv. Vet. Akad. Handl. **1853:** 126 (1854); Robinson (1), 112. *Nephrodium paleaceum* (Hook.f.) Diels, Nat. Pfl. **1**[4]**:** 177 (1899). *Dryopteris furcata* (Kl.) O. Ktze. Rev. Gen. **2:** 812 (1891); Stewart (1), 18.—ALBEMARLE ISL.: Iguana Cove, *Snodgrass & Heller* no. 113 (G); lava caverns, Villamil, 1350 ft., *Stewart* no. 959 (NY); upper regions, Villamil, *Stewart* no. 965 (NY). CHARLES ISL.: *Darwin;* summit of the mountain, *Andersson* (G); Lee (US); *Stewart.* CHATHAM ISL.: southwest end, middle region, *Baur* no. 367 (G), (as *Alsophila* sp.); Wreck Bay, 650 ft., *Stewart* no. 960 (G). INDEFATIGABLE ISL.: *Rorud;* Academy Bay, 550 ft., *Stewart* no. 963 (G); Academy Bay, at the Plantation Fortuna, 800 ft., *Svenson* nos. 105, 106. JAMES ISL.: *Darwin;* James Bay, 2750 ft., *Stewart* no. 962 (G, NY).

Darwin's collections are represented by two sheets; the specimens of Capt. Wood and Capt. Markham at Kew (without further locality) are poorly prepared, but unquestionably the same. *D. ampla*, according to Christensen (l.c.), is known from "the northern Andes of Venezuela, Colombia and Ecuador to Costa Rica and Guatemala, Jamaica and Cuba, from where it has found its way to Florida, and the southern Lesser Antilles from Trinidad to St. Vincent."

D. COLUMBIANA C. Chr. Vid. Selsk. Skr. **7**[4]**:** 279, fig. 8 (1907); Vid. Selsk. Skr. **10**[2]**:** 137 (1913).—INDEFATIGABLE ISL.: Academy Bay, damp openings at 1500 to 2000 ft., *Svenson* nos. 216 and 219. CHARLES ISL.: *Stewart* no. 909 (G) (as *D. parasitica*). CHATHAM ISL.: *Capt. Wood* (an unidentified specimen at Kew). Further distribution: Colombia, Panama.

The material which I have cited under this name is not exactly homogeneous, and it would perhaps be as well to have called it *D. pilosula* (Kl. et Karst.) Hieron. In fact it combines the characteristics of these two species as they are treated by Christensen, who was not at all times certain of their specific distinction. These terrestrial ferns of the *Lastraea* group do not appear to be abundant in the Galapagos Islands, being confined apparently to the moist, windward slopes of the mountains. However, I noted that they occurred fairly commonly from 1500 ft. to 2000 ft. eleva-

tion on Indefatigable Island, the fronds of specimens (no. 219) collected at the lower elevation being comparatively thin, and with the short rachis-pubescence of *D. columbiana*. The collection from 2000 ft. (no. 216), on the other hand, had distinctly coriaceous fronds, and the longer rachis-pubescence of *D. pilosula*. But the two types of rachis-pubescence often vary in fronds of the same clump, and indeed, in different portions of the same frond. The development of leathery texture is undoubtedly associated with the rapidly dwarfing character of the vegetation as one approaches the mountain-summits, and this leathery texture is probably correlated to Christensen's characterization of *Dryopteris ampla* as found in the Galapagos Islands (1920, p. 52), "At best it is a dwarfy form developed in exposed localities on the high mountains of the islands." Capt. Wood's collection closely resembles my no. 219.

The characteristic rigid hairs of *D. columbiana*, on the veins of the upper segment surface, are not particularly well developed in the Galapagos specimens (more developed in no. 216 than in no. 219), which tend also to be more pubescent than in the type collection of *D. columbiana* (NY). The apical portions of young fronds in the Galapagos specimens show very well the character of the indusium, which is reniform to ovate. The indusial hairs (5–9) are all marginal, except that a single one is frequently present in no. 216 at the upper surface, at the point of attachment of the indusium. The character of the indusium agrees, so far as I can make out with the type collection of *D. columbiana*, and not with *D. pilosula*, which tends to have a number of hairs on the upper indusial surface. The margin of the indusium is quickly folded up by the developing sporangia, and soon buried among the mature sporangia, so that the sorus often appears to be non-indusiate.

*D. GLANDULOSA (Desv.) C. Chr. var. BRACHYODUS (Kunze) C. Chr. Vid. Selsk. Skr. ser. 7, **10²**: 172 (1913). *D. brachyodus* (Kze.) O. Ktze. Rev. Gen. Pl. **2**: 812 (1891); Stewart (1), 18. *Nephrodium brachyodon* Hook. Sp. Fil. **4**: 83 (1862); Rob. (1), 110.—Known only from the collection by *Capt. Wood* (Kew), where no further locality is given. Specimens are cited by Christensen from Guatemala to Colombia; the type coming from Pompayaco, Peru.

D. GONGYLODES (Schkuhr) O. Ktze. Rev. Gen. Pl. **2**: 811 (1891); C. Chr. Vid. Selsk. Skr. ser. 7, **10²**: 193 (1913). *Nephrodium unitum* R. Br.; Rob. (1), 110.

Listed by Dr. Robinson on the strength of Caruel's determination of Chiercha's collection. The species is close to *D. mollis*, and the Galapagos specimen probably represents either that species or *D. columbiana*.

D. dentata (Forsk.) C. Chr. Vid. Selsk. Skr. ser. 8, **6¹**: 24 (1920). *D.*

mollis (Jacq.) Hieron. Hedwigia **46:** 348 (1907); C. Chr. Vid. Selsk. Skr. ser. 7, **10²:** 191 (1913).—JAMES ISL.: *Stewart* no. 915 (G) (as *D. tricholepis*), and perhaps some of his collections listed under *D. parasitica*. Lee's collection from Charles Island is doubtfully placed under *D. mollis* by Christensen (1913). By the same author (Dansk Bot. Arkiv. **7:** 49 (1932)), and by Maxon, Bot. Porto Rico and Virgin Ids. **6³:** 470 (1926), *D. mollis* is treated as a synonym of *D. dentata* (Forsk.) C. Chr.

D. PATENS (Sw). O. Ktze., Rev. Gen. Pl. **2:** 813 (1891); C. Chr. Ark. f. Bot. **9¹¹:** 28, fig. 6 (1910) and Vid. Selsk. Skr. ser. 7, **10²:** 176 (1913). *Nephrodium molle* Schott, sensu Hook.f. (1), 171 (1847); Rob. (1), 110. *Dryopteris parasitica* (L.) O. Ktze., Stewart (1), 19, in large part.—CHARLES ISL.: 1000 ft., *Stewart* nos. 908 (K), 910 (NY). CHATHAM ISL.: *Capt. Wood* (K), as *Nephrodium molle*. INDEFATIGABLE ISL.: *Rorud*; Academy Bay, 850 ft., plants 4–5 ft. high, *Svenson* no. 133. JAMES ISL.: *Darwin* (as *N. molle*); James Bay, 2000 ft., *Stewart* no. 913 (K). Distributed throughout tropical America.

Dryopteris pleiosora (Hook.f.) n. comb. *Polypodium pleiosorum*[9] Hook.f. Trans. Linn. Soc. **20:** 166 (1847) (as *pleiosoros*); Rob. (1), 113; Stewart (1), 25. *Nephrodium villosum* sensu Rob. (1), 110; non Presl. *Dryopteris villosa* sensu Stewart (1), 20; non Ktze. *Dryopteris tricholepis* sensu Stewart (1), 19 (partim); non (Bak.) C. Chr.—JAMES ISL.: *Darwin* (TYPE in herb. Cambridge Univ.). CHATHAM ISL.: Wreck Bay, common in moist places at 2000 ft., *Stewart* no. 914 (Cal, NY) (as *D. tricholepis*). GALAPAGOS IDS.: *Capt. Wood* (as *Polypodium Berteroanum*).

Darwin's specimen, which I examined at Cambridge, is the same as Capt. Wood's at Kew, the latter being slightly more hairy on the lower surface. Stewart's specimen at the California Acadamy of Sciences represents an entire frond with scattered and comparatively few sori; that at New York is very small and immature, but fortunately has the entire base which shows the typical *Ctenitis* scales exceptionally well. Throughout the rachis these scales appear to be homogeneous, a deep glossy brown,

[9] P. PLEIOSOROS, *Hook. fil.*; fronde ovatâ bipinnatâ, pinnis linearibus elongatis acuminatis; pinnulis lineari-oblongis approximatis apicibus rotundatis inferioribus grossè crenato-dentatis suprà pilis sparsis hirtis subtùs molliter pubescentibus, soris 10–14, rachibus costisque pubescentibus paleaceisque.
Hab. James Island, *Charles Darwin, Esq.*

Rachis paleacea pilisque brevibus albidis obsita, paleis elongatis brunneis. Pinnae 6 unc. longae, ad medium lineares deinde ad acumen gradatim attenuatae, 1 unc. latae. Pinnulae sub-50, ½–⅔ unc. longae, ¼ latae, sessiles, membranaceae v. subcoriaceae, supernè confluentes, suprà pubescentes, subtùs pilosae, pilis sparsis elongatis, marginibus supernè crenatae. Sori plurimi, medio venulae inter costam marginemque siti.

with well-developed marginal teeth. Short reddish articulate hairs occur abundantly on the lower surfaces of the frond, being replaced on the upper surfaces of the pinna-axis and the costules (especially on the nerves) by appressed subulate whitened hairs (of 4–6 cells, and averaging 0.2 mm. long), which make the surface somewhat glistening (at least in the Stewart specimens) and give a ciliate appearance to the margins of the segments. In addition, short two to three-celled hairs with a bulbiform apex (i.e. glandular) are found in mature segments (lacking in specimens at NY). The segments toward the middle of the frond are conspicuously crenate-dentate.

Capt. Wood's specimen, cited with doubt by Hooker (Sp. Fil. **4:** 270 (1862)) under *Polypodium Berteroanum*, was distinguished as follows: "submembranaceous, segments elongated, lobes shorter, lowest inferior often forming an axillary lobe between two segments, probably distinct." Hooker's judgment seems to have been correct; the Galapagos plant is quite different from *Dryopteris inaequalifolia* (Colla) C. Chr. Vidensk. Skr. ser. 8, **6**[1]**:** 73 (1920), [*Polypodium Berteroanum* Hook., not Sprengel] which is confined to Juan Ferandez, and has tripinnate fronds and prominent reddish scars on the stipe, left by the fallen scales. *D. tricholepis* (Bak.) C. Chr. is illustrated by Christensen (Vidensk. Selsk. Skr. ser. 7, **10**[2]**:** 107, fig. 10d (1913)), and is obviously quite different from *D. pleiosora*, being an indusiate Guatemalan species with generally glabrous lower surfaces.

D. POITEANA (Bory) Urban, Symb. Ant. **4:** 20 (1903); C. Chr. Vidensk. Selsk. Skr. ser. 7, **10**[2]**:** 265 (1913). *Dryopteris reticulata* sensu Stewart (1), 19; not (L.) Urban.—INDEFATIGABLE ISL.: Academy Bay, occasional in damp woods, 800 ft., *Svenson* no. 107; Academy Bay, above 550 ft., *Stewart* no. 900 (Cal). According to Christensen (l.c.), *D. Poiteana* is a wide-ranging species found in most of the West Indian Islands and from Guatemala to Peru.

*D. RUDIS (Kze.) C. Chr. Ind. 289 (1905); Stewart (1), 19. *Polypodium rude* Kze. Linnaea **13:** 133 (1839); Hook. Sp. Fil. **4:** 243 (1862). Known only from the citation by Hooker (l.c.) "Galapagos, Wood?," and I could not locate the specimen at Kew.

D. TETRAGONA (Sw.) Urban, Symb. Ant. **4:** 20 (1903). *D. pseudotetragona* Urban; Stewart (1), 19.—INDEFATIGABLE ISL.: the moist zone, December, 1926, *Rorud* no. 255; Academy Bay, in underbrush in damp places along trail, 700 ft., *Svenson* no. 117; Academy Bay, common in dense shade above 550 ft., *Stewart* no. 884 (Cal).

Christensen (l.c.) notes that the specimens collected by Miss Rorud are probably to be referred to a distinct form. The cutting of the pinnae

in no. 117 is very shallow, in this respect closely resembling the illustration of *D. Rolandii* C. Chr. Vid. Selsk. Skr. ser. 7, **10²:** 258, fig. 45 (1913). The sporangia are not spinescent as in *D. Rolandii*.

ELAPHOGLOSSUM Schott

E. PETIOLATUM (Sw.) Urban, Symb. Ant. **4:** 61 (1903); Stewart (1), 20. *Acrostichum muscosum* sensu Rob. (1) 104; non Sw. *A. viscosum* Sw.; Rob. (1) 105. *Elaphoglossum muscosum* (Sw.) Moore; Stewart (1), 20.—ALBEMARLE ISL.: *Stewart* no. 775 (Cal). (as *E. muscosum*). JAMES ISL.: *Darwin* (two sheets). The specimen noted as *Olfersia Langsdorfii* by Hook. f. (Trans. Linn. Soc. **20:** 167 (1847)), has a linear-elliptic fertile frond with a long portion of the stipe. No scales appear on the rachis or elsewhere. The second *Darwin* specimen bears the annotation "very near *Acrostichum viscosum* var. *glabriusculum*." Both should be included under *E. petiolatum;* apparently the scaly-stiped *E. muscosum* (Sw.) Moore, is unknown from the Galapagos Islands.

HEMITELIA R. Br.

H. aff. SUBCAESIA Sodiro, Cr. Vasc. Quit. 522 (1893). *H. multiflora* sensu Stewart (1), 20; not (Sm.) R. Br.—ALBEMARLE ISL.: *Stewart.* CHATHAM ISL.: *Stewart.* JAMES ISL.: *Stewart.*

Stewart's collections (nos. 895–7) are quite different from true *H. multiflora* (illustrated by Maxon, Bull. Torrey Club **38:** 545–550, pl. 35 (1911)). They have the general appearance of *Cyathea purpurea* of the West Indies. The large indusium is half-circular at the base, but cucullate and covering the entire sorus. The entire lower surface of the pinnules—at least in the younger stages—is covered by large appressed, flattened, ashy-gray scales, usually with hardened filamentous appendages. These are intermingled with smaller trichome-like scales and rigid short-jointed hairs.

HISTIOPTERIS Agardh

*H. INCISA (Thunb.) J. Sm. Hist. Fil. 295 (1875); *Stewart* (1), 21. *Pteris incisa* Thunb. Prod. Fl. Cap. 171 (1800); Rob. (1), 114.—The only specimen which I have seen is the collection by *Capt. Wood* (Kew), cited by Hooker, Sp. Fil. **2:** 230 (1858). It consists of typical material with soft rounded pinnae, not yet in the fruiting stage. Stewart's misidentified collections (Cal) are *Pteridium arachnoideum* (no. 997) and *Pteris biaurita* (nos. 998, 999, 1000).

HYMENOPHYLLUM Sm.

H. CILIATUM Sw. in Schrad. Journ. **1800²:** 100 (1801). *H. hirsutum* sensu Stewart (1), 21; not (L.) Sw.—CHATHAM ISL.: Wreck Bay, *Stewart* no. 898 (US).

Hypolepis Bernh.

H. REPENS (L.) Presl, Tent. Pterid. 162 (1836); Rob. (1), 109; Stewart (1), 21. *Lonchitis repens* L. Sp. Pl. 1078 (1753).—INDEFATIGABLE ISL.: Academy Bay, common in clearings, 800 ft., *Svenson* no. 109; south slope of mountain, 1625 ft., *Svenson* no. 131; 4-6 ft. high, forming much of the fern vegetation at 2000 ft., *Svenson* no. 147. GALAPAGOS IDS.: *Capt. Wood* (Kew), a poor specimen, cited by Hooker, Sp. Fil. **2:** 64 (1858).

Nephrolepis Schott

N. BISERRATA (Sw.) Schott, Gen. Fil. ad t.3 (1834); Stewart (1), 21. *Nephrolepis acuta* Presl, Tent. Pterid. 79 (1836); Rob. (1), 110.—ABINGDON ISL.: 1650 ft. *Stewart.* ALBEMARLE ISL.: Villamil, near the shore, *Stewart* no. 921 (G). BINDLOE ISL.: common in the interior, *Stewart* no. 918 (G); *Snodgrass & Heller* no. 779 (G). WENMAN ISL.: in lava coverns and on cliffs, *Stewart* no. 919.

N. PECTINATA (Willd.) Schott, Gen. Fil. ad t.3 (1834); Rob. (1), 110; Stewart (1), 22. *Nephrodium pectinatum* Presl; Hook.f. Trans. Linn. Soc. **20:** 170 (1847).—ABINGDON ISL.: 1950 ft., *Stewart.* ALBEMARLE ISL.: Villamil, 1350 ft., *Stewart.* CHATHAM ISL.: Wreck Bay, 1800 ft., 2100 ft., *Stewart* no. 926 (G); southwest end, *Baur* no. 357 (G). DUNCAN ISL.: 1300 ft., *Stewart.* INDEFATIGABLE ISL.: Academy Bay, above 500 ft., *Stewart;* Academy Bay, an abundant epiphyte at 1100–1600 ft., *Svenson* no. 127; forming fern banks on the ground at 2000 ft., *Svenson* no. 222. JAMES ISL.: James Bay, lava crevices at 2150–2850 ft., *Stewart* no. 923 (G); *Darwin* (represented by two sheets), (as *Nephrodium pectinatum*).

Notholaena R. Br.

Notholaena galapagensis Weatherby & Svenson, sp. nov. (Pl. 9, fig. 2). Rhizoma obliquum, breve repens, (2–4 cm. longum, 3 mm. diametro) paleis rigidis, reticulatis castaneis vel mature brunnescenti-fuscis lanceolatis vel lanceolato-ovatis (4–5 mm. longis, 1.3 mm. latis) haud denticulatis acuminatis concoloribus margine pallidiore angustissimo saepe fere obsoleto excepto vestitum; folia subcoriacea, supra glabra, infra pulvere ceracea, subsulphurea obtecta; petiolus 4–12 cm. longus, brunneosubnitidus, ad basim paleis nonnullis divaricatis, semi-deciduis, brunnescenti-fuscis concoloribus reticulatis, attenuatis (3–3.5 mm. longis, 1 mm. latis) obsitus; lamina 5–11 cm. longa, 3–5 cm. lata ovato-oblonga bipinnatifida, deorsum in segmento primario tripinnatisecta; segmenta primaria opposita vel subopposita, infima 3 cm. distantia (3–4 cm. longa), breviter petiolata, anguste deltoideo-ovata, superiora sessilia oblonga, apice attenuata obtusa, pinnatipartita; laciniae vel segmenta secundaria coadunata oblonga obtusa, latere inferiore segmentorum infimorum non

auctis, omnia margine levissime crenulata; nervi immersi; sori nigricantes oligocarpi, frequenter monocarpi, sporangio maturo magno (330μ diametro), massae ceraceae immersi, lineam intramarginalem efformantes, basi lobulis non scariosis cincti. *N. candidae* affinis, a qua inter aliis, squamis concoloribus segmentis infimis aequilateralibus stipite brunneo differt. *N. candida* (M. & G.) Hook. var. *lutea* (Cav.) Hook. Sp. Fil. **5:** 111 (1864) as to plant, not as to name-bringing synonym. *Pteris lutea* sensu Hook.f. Trans. Linn. Soc. **20:** 168 (1847), not Cav. Descr. 267 (1802). *N. sulphurea* sensu Rob., Proc. Am. Acad. **38:** 111 (1902); Stewart, Proc. Cal. Acad. Sci. ser. 4, **1:** 22 (1911); not J. Sm. in Seem. Bot. Voy. Herald 233 (1854), based on *Pteris sulfurea* Cav. Descr. 269 (1802).—ALBEMARLE ISL.: *Snodgrass & Heller; Stewart.* INDEFATIGABLE ISL.: Academy Bay, dry lava cliffs of escarpment at 100 ft., *Svenson* no. 79. JAMES ISL.: *Scouler* (Kew); *Stewart.* NARBOROUGH ISL.: *Stewart.* GALAPAGOS IDS.: *Cuming* no. 110 (Kew). As the TYPE, *Snodgrass & Heller* no. 23 (Gray Herbarium) from Iguana Cove, Albemarle Island is designated.

Historically Hooker's (1847) identification of Scouler's and Cuming's plants as *Pteris lutea* rested only on Sprengel's brief description (Syst. **4:** 74 (1827)), in turn based on Cavanilles' description of a Mexican plant. Later Hooker (1864) treated the Galapagos plants as *Notholaena candida* without ascribing them to any definite variety, although the var. *lutea* in Hooker's somewhat confused account was made to include collections from Peru by Mathews and by Gillies. By Hooker & Baker (Syn. Fil. 373 (1868)), *N. candida* was further merged into the synonymy of *N. sulphurea* J. Sm., quite evidently the source of Dr. Robinson's employment of the latter name, which applies to a tripartite Mexican species.

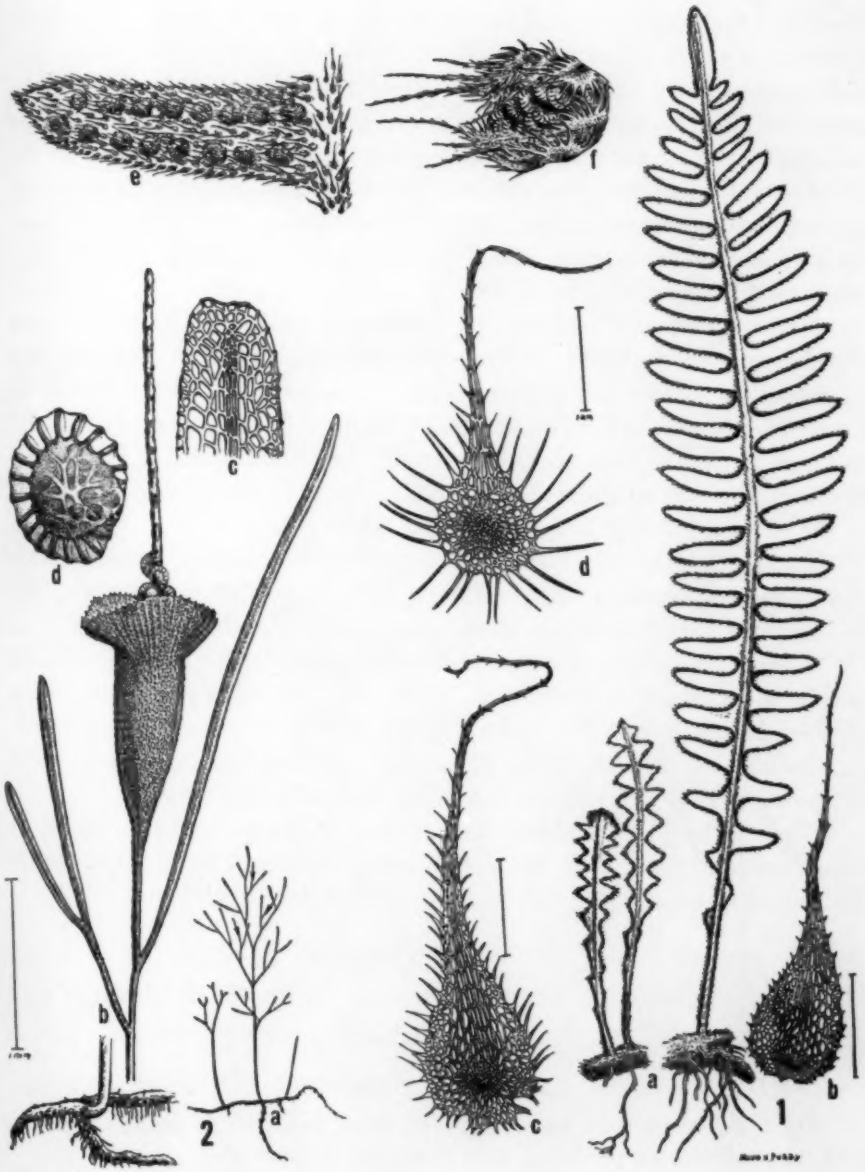
In reviewing the identity of *Pteris aurantiaca* and *P. lutea*, Christensen (Arkiv. f. Bot. **9²:** 42 (1900) and Dansk Bot. Arkiv. **60,** no. 3: 22 (1937)) finds that both are the same species i.e. *Cheilanthes lutea* (Cav.) Moore.

The yellow cera of the Galapagos plant consists of small stalked crateriform extrusions which are often linked up in the mature frond into a cobwebby mass. The sori are partially (sometimes wholly) covered by the revolute margin of the young frond; the mature sori are borne just within the revolute margin, only one sporangium in each sorus usually maturing. The sessile hemispheric sporangia average 330μ in width; the smooth dusky olivaceous spores are about the size of the spores of *Pellaea atropurpurea.*

Explanation of Plate 8

Fig. 1. POLYPODIUM LEPIDOPTERIS (no. 231): a, habit ×½. b, scale from rhizome. c, scale from stipe. d, scale from lower surface of pinna. e, lower surface of pinna (×2). f, sorus, with adjacent scales.

Fig. 2. TRICHOMANES COCOS (no. 349): a, habit ×½. b, details of rhizome and tip of frond. c, apex of segment. d, sporangium.


e
f
c
d
d
b
2
a
c
a
1
b

The margin of the frond is unmodified, the cerate to somewhat glandular edge being without scales or hyaline tissue. Veins show only in the basal lobule of each segment, and as the midrib of the segment. The entire situation is much the same as in *E. J. Palmer* no. 13608 (*Notholaena candida*) except for a tendency in the latter toward transformation of the frond margin, thinner frond with obvious venation, and cerous trichomes (of different color than in *N. galapagensis*) on the upper surface of the frond as well as on the lower surface. *N. candida* also differs in having more approximate pinnae with linear-lanceolate divisions. The Galapagos plant is obviously not the same species; the difference is clear in illustrations by Martens & Galeotti and by Eaton.

Of the six species included by Mettenius (1859) in the group with fronds cerate on the lower surface, only *Cheilanthes affinis*, *C. candida*, and *C. monosticha* have lanceolate fronds. *C. monosticha* Mett. (based on *Ceropteris monosticha* Fée, Mém. **7:** 44, t.22, fig. 2 (1857) came from Mexico and was known to Mettenius only from Fée's description and plate. By Mettenius it was considered as scarcely distinct from *C. candida* except in the presence of a yellow instead of a white cera.

Hooker & Baker (l.c.) included several of Mettenius' species within *Notholaena sulphurea* J. Sm., with the following notation (p. 374): "We include here four species of Mettenius. His *C. Borsigiana*, Reichb., has the pinnae very close, and the lower pair much larger than the others, within the powder bright-yellow. From this *C. cretacea* seems to differ only by its white powder, and there are various intermediate stages. In *C. candida* and *monosticha* the pinnae are not so close and less unequal, the powder being white in the first and yellowish in the latter."

The type of *C. Borsigiana*, the only one of the group based on South American material (Peru), has been recently examined by Mr. Weatherby and found to be no more than a form of *Notholaena sulphurea*.

Pityrogramma Link

P. calomelanos (L.) Link, Handb. Gew. **3:** 20 (1833); Maxon, Contr.

Explanation of Plate 9

Fig. 1. Polypodium aff. steirolepis (no. 93): a, habit ×½. b, scale from rhizome with (c) detail of lower portion. d, scale from stipe. e, sporangium.

Fig. 2. Notholaena galapagensis (no. 79): a, habit ×½. b, scale from rhizome. c, scale from stipe. d, sterile pinnule, showing venation. e, fertile pinnule, showing margin. f, sporangium. g, cera (much enlarged).

Fig. 3. Diplazium aff. subobtusum (no. 132): a, portion of frond, ×½. b, detail of lower part of a pinnule.

a
3
b
d
f
e
1
g
a
b
d
c
a
b
2
c

U. S. Nat. Herb. **17:** 173 (1913). *Ceropteris tartarea* (Cav.) Link; Stewart (1), 16. *Gymnogramma tartarea* Desv. Berl. Mag. **5:** 305 (1811); Rob. (1), 109.—ALBEMARLE ISL.: *Snodgrass & Heller; Stewart.* BINDLOE ISL.: *Stewart.* CHARLES ISL.: *Stewart.* CHATHAM ISL.: *Chiercha; Stewart; Baur.* DUNCAN ISL.: *Stewart.* INDEFATIGABLE ISL.: Academy Bay, locally in moist places among boulders, 1000–1100 ft., *Svenson* no. 218. JAMES ISL.: *Stewart.*

P. PRESLIANA Domin, var. AURATA Dom. Publ. Fac. Sci. Univ. Charles **88**[6]**:** 19, t.1 (1929). *Gymnogramme tartarea* var. *aurata* Moore, Gard. Chron. 493 (1870).—BINDLOE ISL.: *Snodgrass & Heller* no. 778 (G), a juvenile specimen with flabellate fronds which are yellow-powdered on the under surface.

POLYPODIUM L.

P. ANGUSTIFOLIUM Sw. Prod. 130 (1788); Rob. (1), 111; Stewart (1), 23. *Marginaria ensifolia* Presl; Hook.f. Trans. Linn. Soc. **20:** 167 (1847).—JAMES ISL.: *Darwin;* James Bay, 2100 ft., *Stewart* no. 935. Darwin's specimen at Cambridge is very doubtfully this species, and most probably *P. lanceolatum.*

P. AUREUM L. Sp. Pl. 1087 (1753); Rob. (1), 111; Stewart (1), 23. *Pleopeltis aurea* Hook.f. Trans. Linn. Soc. **20:** 167 (1847).—ALBEMARLE ISL.: *Stewart.* DUNCAN ISL.: *Stewart.* JAMES ISL.: *Stewart.* GALAPAGOS IDS.: *Darwin; Capt. Wood.* The monstrous specimen collected by Darwin, which Hooker (l.c.) mentions, is clearly this species. I was unable to find Capt. Wood's specimen at Kew.

P. CRASSIFOLIUM L. Sp. Pl. 1083 (1753); Rob. (1), 112. Stewart (1), 23.—ALBEMARLE ISL.: Tagus Cove, *Stewart* no. 941 (perhaps *P. Phyllitidis*). GALAPAGOS IDS.: *Capt. Wood* (two sheets at Kew).

P. LANCEOLATUM L. Sp. Pl. 1082 (1753); Rob. (1), 112; Stewart (1), 23. *Pleopeltis macrocarpa* Kaul.f.; Hook.f., Trans. Linn. Soc. **20:** 167 (1847). *Pleopeltis lepidota* Willd.; Hook.f. (l.c.).—ALBEMARLE ISL.: *Snodgrass & Heller; Stewart.* CHARLES ISL.: *Darwin; Andersson; Stewart.* DUNCAN ISL.: *Stewart.* INDEFATIGABLE ISL.: *Stewart;* Academy Bay, epiphyte, 400 ft., *Svenson* no. 56; 2000 ft., *Svenson* no. 213. JAMES ISL.: *Darwin.* Darwin's plant from James Island has wide fronds (3.3 cm.) identical with no. 213; his collection from Charles Island has fronds only 1 cm. wide.

P. LEPIDOPTERIS (Langsd. & Fisch.) Kze. Linnaea **13:** 132 (1836), sensu lat.; Hook. Sp. Fil. **4:** 212 (1862); Rob. (1), 112; Stewart (1), 23. ALBEMARLE ISL.: *Stewart.* DUNCAN ISL.: *Stewart.* INDEFATIGABLE ISL.: *Stewart;* Academy Bay, abundant epiphyte at 500 ft., *Svenson* no. 231

(Pl. 8, fig. 1). JAMES ISL.: *Stewart.* GALAPAGOS IDS.: *Capt. Wood* (2 sheets, the glistening, almost micaceous texture of the under surface, and the isolated deep brown scales of the rachis being especially noticeable). Stewart's nos. 452, 954, 955, and 956 are this species.

*P. LORICEUM L. Sp. Pl. 1086 (1753); Rob. (1), 112; Stewart (1), 24. Moore, Ind. Fil. 392 (1862).—GALAPAGOS IDS.: *Capt. Wood.* This collection at Kew (apparently the basis of Moore's citation) is identical with specimens collected by Seemann at the Bay of Cupica in 1848. Only a portion of the blade is present. This exceeds 40 cm. in length and 14 cm. across, with the acute pinnae up to 1.5 cm. wide, and the sori in several (often 4) rows.

P. PECTINATUM L. Sp. Pl. 1085 (1753); Rob. (1), 113; Stewart (1), 24. *P. paradiseae* Langsd. & Fisch. Ic. Fil. 11, t. 11 (1810–1818); Hook.f. Trans. Linn. Soc. **20:** 165 (1847).—ABINGDON ISL.: *Stewart.* ALBEMARLE ISL.: *Snodgrass & Heller; Stewart.* CHARLES ISL.: *Andersson; Stewart.* CHATHAM ISL.: *Chiercha; Baur; Stewart.* INDEFATIGABLE ISL.: *Stewart;* Academy Bay, common on ground in underbrush 350–600 ft., *Svenson* no. 74. JAMES ISL.: *Darwin; Stewart.*

*P. PERCUSSUM Cav. Descr. 243 (1802); Hook. Fil. Exot. t. 59 & Sp. Fil. **5:** 56 (1864); Rob. (1), 113; Stewart (1), 24.—GALAPAGOS IDS.: *Capt. Wood* (Kew). The frond is 3 cm. in diameter with prominent sori.

P. PHYLLITIDIS L. Sp. Pl. 1083 (1753); Rob. (1), 113; Stewart (1), 24. *Campyloneuron Phyllitidis* Presl; Hook.f. Trans. Linn. Soc. **20:** 167 (1847). —INDEFATIGABLE ISL.: Academy Bay, 550 ft., *Stewart* no. 940 (Cal) (2 sheets, as *P. crassifolium*) (no. 941 not seen); Academy Bay, in shaded undergrowth near entrance to Plantation Fortuna, 700 ft., *Svenson* no. 114, and not uncommon to 1000 ft. JAMES ISL.: *Darwin;* above 1500 ft., *Stewart* no. 969. Also probably represented by "large sword ferns" (Stewart l.c.) on Abingdon Island.

P. POLYPODIOIDES (L.) Watt, Canad. Nat. II. **13:** 158 (1867). *Polypodium incanum* Sw. Prod. 131 (1788); Hook.f. Sp. Fil. **4:** 209 (1862); Rob. (1), 112 (only as to Capt. Wood's collection).—ALBEMARLE ISL.: Villamil, common on the trunks of trees at 600 ft., *Stewart* no. 944. INDEFATIGABLE ISL.: Academy Bay, on the trunks and branches of trees above 425 ft., *Stewart* no. 942; southeast side, common on tree trunks at 625 ft., *Stewart* no. 943; *Rorud* no. 259. CHATHAM ISL.: *Capt. Wood,* a small specimen 6–7 cm. high, scales short and somewhat rufous.

P. aff. STEIROLEPIS C. Chr. Amer. Fern Journ. **7:** 33 (1917). *P. thyssanolepis* sensu Stewart (1), 26; not A. Br. ex Klotzsch.—ALBEMARLE ISL.: Villamil, abundant at 600 ft., on trees at 1300 ft., *Stewart* nos. 989 (Cal), 990 (Cal). INDEFATIGABLE ISL.: Academy Bay, epiphyte at 2000

ft., *Svenson* no. 93 (Pl. 9, fig. 1). JAMES ISL.: occasional on trunks of trees, 2750 ft., *Stewart* no. 991 (Cal).

Dr. Maxon has very kindly furnished the following comments on the specimens of my collection (no. 93):

> The venation . . . is anomalous, being imperfectly goniophlebioid, with an occasional indication of phlebodioid venation. Plants having the general aspect of no. 93 have commonly been referred to *P. leucosticton* Kunze, but mistakenly so, inasmuch as that species has winged stipes and free venation. Your plant is obviously related to *P. steirolepis* C. Chr., but that very critical species, as shown by several recent specimens, has definitely phlebodioid venation.
>
> Another species that must be taken into account in this connection is *P. Fraseri* Mett., described from Ecuador. I have not seen the type of this or any authentic material; but I have removed from our cover of *P. leucosticton* a good many specimens from Colombia, Peru, and Ecuador which I now refer here tentatively, assuming that Mettenius's description was drawn from an under-sized specimen. In the character of the rhizome scales and in all real diagnostic features these plants agree with the description of *P. Fraseri*, and I think I am correct in referring them to that species, which in its rhizome scales (but not in several other characters) shows a very definite affinity to *P. leucosticton*. Your no. 93 can not be referred here nearly so well as to *P. steirolepis*, and my best judgment would be that you refer it, for the present, tentatively to *P. steirolepis*. It bears a very close *general* appearance to plants of that species and differs mainly in its less complicated venation. Possibly no. 93 represents a new species, but more probably it can be connected with typical *P. steirolepis* by plants showing intermediate stages of venation, when sufficient new material has been collected.

P. TRIDENS Kze. Farnkr. **1:** t. 13, fig. 1 (1840); Hook. Sp. Fil. **4:** 210 (1862). *P. squamatum* sensu Rob. (1), 113; Stewart (1), 25; not L. *Marginaria incana* Hook.f. Trans. Linn. Soc. **20:** 166 (1847); Rob. (1), 113 (in part).—ABINGDON ISL.: *Snodgrass & Heller; Stewart.* ALBEMARLE ISL.: *Snodgrass & Heller; Stewart.* BINDLOE ISL.: *Snodgrass & Heller; Stewart.* CHARLES ISL.: *Darwin; Andersson; Capt. Markham* (Kew); *Lee; Baur; Stewart.* CHATHAM ISL.: *Capt. Wood; Snodgrass & Heller; Baur; Stewart.* DUNCAN ISL.: *Baur; Snodgrass & Heller; Stewart.* INDEFATIGABLE ISL.: *Stewart; Rorud;* terrestrial in thickets, half hidden by bushes, 500 ft., *Svenson* no. 73 (occasional at 250 ft., common at 450–600 ft.). JAMES ISL.: *Stewart.* JERVIS ISL.: *Stewart.* NARBOROUGH ISL.: *Stewart.* GALAPAGOS IDS.: *Cuming* no. 112.

Marginaria incana, from the Galapagos Islands, was known by Hooker as "*var.* frondibus plerumque pinnatis, pinnis inferioribus 2–3 furcatis." Darwin's specimens are *P. tridens*, as are also, without serious question, those of Macrae (specimens not seen). The collection by Capt. Markham has one pinna with five segments; otherwise it is like Cuming's type collection.

POLYSTICHUM Roth

P. aff. PYCNOLEPIS Moore, Ind. 92 (1858). *P. aculeatum* sensu Stewart (1), 26; not (L.) Schott. ALBEMARLE ISL.: Villamil, 3150 ft., *Stewart* no. 802 (Cal).

P. ADIANTIFORME (Forst.) J. Sm. Hist. Fil. 220 (1875); Stewart (1), 26. *Aspidium coriaceum* Sw. in Schrad. Journ. Bot. **1800**[2]: 40 (1801); Rob. (1), 106; *Polystichum coriaceum* Presl; Hook.f. Trans. Linn. Soc. **20:** 171 (1847).—ALBEMARLE ISL.: Villamil, 3150 ft., *Stewart* no. 803 (Cal.) JAMES ISL.: *Darwin*. Darwin's two specimens agree well with other South American collections.

PTERIDIUM Gled.

P. ARACHNOIDEUM (Kaulf.) Maxon, Journ. Wash. Acad. Sci. **14:** 89 (1924). *P. aquilina* var. *esculenta* Hook.f. Fl. N. Zeal. **2:** 25 (1855) and Hook. Sp. Fil. **2:** 198 (1858); Rob. (1), 114; Stewart (1), 26.—ABINGDON ISL.: forms extensive brakes on the south side of the island above 1600 ft., *Stewart* no. 992; occasional around 1950 ft., *Stewart* no. 997 (Cal.) (as *Histiopteris incisa*). ALBEMARLE ISL.: *Snodgrass & Heller; Stewart*. CHATHAM ISL.: *Baur; Stewart*. INDEFATIGABLE ISL.: Academy Bay, forming thickets at 2000 ft., *Svenson* no. 212. GALAPAGOS IDS.: *Capt. Wood*, the collection closely resembling no. 212.

PTERIS L.

*P. PROPINQUA var. CUMINGIANA Ag. Sp. Gen. Pterid. 65. (1839); Hook. Sp. Fil. **2:** 223 (1858); Rob. (1), 115; Stewart (1), 26.—CHATHAM ISL.: *Capt. Wood*. The specimen at Kew, labeled "Chatham I." closely resembles *Spruce* no. 5708 from Guayaquil. In addition to the citation from the Galapagos Islands, var. *Cumingiana* is also mentioned by Hooker (l.c.) from Mexico to Venezuela and from the West Indies, and he further notes: "Of this *Pt. propinqua* I may observe, it will be difficult to distinguish it from some states of *Pt. aculeata*, Sw.; and the var. *Cumingiana* with its more rigid fronds, shorter more falcate, and often more mucronate segments, is, I fear, identical with *P. apicalis* of Liebmann." Capt. Wood's specimen apparently is the same as a fragment of the type collection at the U. S. National Herbarium.

P. QUADRIAURITA Retz. Obs. **6:** 38 (1791). *Histiopteris incisa* sensu Stewart (1), 21; not (Thbg.) J. Sm.—ALBEMARLE ISL.: *Stewart* nos. 998 & 1000 (Cal) (as *H. incisa*).—INDEFATIGABLE ISL.: Academy Bay, occasional in shaded underbrush, 800 ft., *Svenson* no. 100. JAMES ISL.: James Bay, *Stewart* no. 999 (Cal) (as *H. incisa*). By Christensen (Index Filicum 593 (1906)), this species is included under *P. biaurita* L.

TECTARIA Cav.

T. MARTINICENSIS (Spr.) Copel. Phil. Journ. Sci. **2c:** 410 (1907). *Aspidium martinicense* Spr. Anleit. **3:** 133 (1804); Stewart (1), 13. *Nephrodium macrophyllum* Bak. Syn. Fil. 300 (1874); Rob. (1), 110.—ALBEMARLE ISL.: *Stewart* no. 902 (Cal). CHATHAM ISL.: *Capt. Wood.* JAMES ISL.: *Stewart* no. 903. Captain Wood's specimens at Kew are the same as Stewart's no. 903.

TRACHYPTERIS André

T. PINNATA (Hook.f.) C. Chr. Ind. 634 (1906); Stewart (1), 27. *Hemionitis pinnata* Hook.f. Trans. Linn. Soc. **20:** 167 (1847). *Acrostichum aureo-nitens* Hook.f. Ic. Pl. **10:** t. 933 (1854); Rob. (1) 104.—ABINGDON ISL.: *Stewart.* ALBEMARLE ISL.: *Snodgrass & Heller; Stewart.* CHARLES ISL.: *Darwin; Andersson; Lee; Baur; Stewart.* CHATHAM ISL.: *Capt. Wood; Stewart.* INDEFATIGABLE ISL.: *Stewart; Rorud;* Academy Bay, abundant on exposed rocks, 100–300 ft. and on lava ledges in damp shaded woods, 400 ft., *Svenson* no. 226. JAMES ISL.: *Stewart.* NARBOROUGH ISL.: *Snodgrass & Heller.* GALAPAGOS IDS.: *Capt. Wood; Capt. Markham.*

This is perhaps the most spectacular fern of the Galapagos Islands. It can maintain itself on bare lava ledges, though fruiting specimens, in my experience, are confined to comparatively damp habitats. In addition, the species is known from the mainland, being represented by the following examples which I have examined; ECUADOR: Andibus merid. circa 3800 m., *E. André* no. 4699 (Kew). PERU: Colpapampa, 9000 ft., *Bues* no. 1339 (US); Toronton, 2000–2800 m., *Herrera* no. 1334 (US); Santa Ana, 900 m., *Cook & Gilbert* no. 1480 (US) & no. 1563 (US). BOLIVIA: Asilla, 3500 ft., *R. S. Williams* no. 1177 (NY); Espia, head of Bopi River, 3500 ft., *Rusby* no. 305 (B, NY).

The Brazilian plant, **T. Gilliana** (Baker) n. comb. (*Acrostichum Gillianum* Baker, Journ. Bot. 310 (1882)) from Arasenahy, Minas Geraes (*Glaziou* no. 1334) and "Catingawald bei Tambury," Bahia, *Ule* no. 7070 (Kew), does not apparently represent the same species as the Bolivian-Ecuadorian material, since in addition to the narrowly-trifid fertile pinnae the scales of the rachis are decidedly opaque as contrasted with the translucent scales of the plant from western South America. Furthermore, the fronds of Glaziou's collection are narrower, and hairy above as well as below. I can find no restriction of sporangia to the veins in dissecting the Galapagos specimens; the sporangia are borne over the *entire* frond surface. The genus would therefore seem to be close to *Elaphoglossum* (cf. however, Christensen, Dansk. Bot. Arkiv. **7:** 110 (1932)).

TRICHOMANES L.

T. KRAUSII Hook. & Grev. Ic. Fil. **2:** t.149 (1831). *Hymenophyllum Polynthos* sensu Stewart (1), 21; not Sw. *Trichomanes pusillum* sensu Stewart (1), 27.; not Sw.—DUNCAN ISL.: in dense tufts on the southeast side of rocks at 1300 ft., *Stewart* no. 899 (Cal) (as *H. polyanthos*). INDEFATIGABLE ISL.: Academy Bay, on dripping rocks, south slope of mountain, 1500 ft., *Svenson* no. 220. JAMES ISL.: James Bay, common on moist tufa walls at 2050 ft., *Stewart* no. 1013 (reported as no. 1012) (Cal) (as *T. pusillum*).

SALVINIACEAE

AZOLLA Lam.

A. FILICULOIDES Lam. Encyc. **1:** 343 (1783). *A. caroliniana* sensu Rob. (1), 115; Stewart (1), 27; not Willd.—CHARLES ISL.: *Andersson; Stewart* no. 3441 (Cal). CHATHAM ISL.: *Stewart* no. 3442 (Cal). INDEFATIGABLE ISL.: abundant on the surface of pools west of Academy Bay, *Svenson* no. 86.

Although I have not seen Andersson's collection (reported as *A. caroliniana*) I have little hesitation in placing it under *A. filiculoides*, coming as it did from the same place as Stewart's collection.

EQUISETACEAE

EQUISETUM L.

E. BOGOTENSE HBK. Nov. Gen. & Sp. **1:** 42 (1815); Stewart (1), 28.—ALBEMARLE ISL.: *Stewart.*

LYCOPODIACEAE

LYCOPODIUM L.

L. CERNUUM L. Sp. Pl. 1103 (1753).—INDEFATIGABLE ISL.: *Rorud.*

L. CLAVATUM L. Sp. Pl. 1101 (1753); Rob. (1), 115; Stewart (1), 28.—CHATHAM ISL.: *Baur; Stewart.* INDEFATIGABLE ISL.: *Rorud;* Academy Bay, abundant at 2000 ft., *Svenson* no. 207. JAMES ISL.: *Stewart.*

L. COMPLANATUM L. Sp. Pl. 1104 (1753); Stewart (1), 28.—ALBEMARLE ISL.: *Stewart.* INDEFATIGABLE ISL.: *Rorud.*

L. DICHOTOMUM Jacq. Enum. Vindob. 314 (1762); Rob. (1), 115; Stewart (1), 28.—ALBERMARLE ISL.: *Stewart.* INDEFATIGABLE ISL.: *Stewart*; Academy Bay, epiphyte, 400 ft. alt., *Svenson* no. 400.

L. REFLEXUM Lam. Encyc. **4:** 653 (1789); Stewart (1), 28.— ALBEMARLE ISL.: *Stewart.*

L. TAXIFOLIUM Sw. Prod. 138 (1788).—CHARLES ISL.: *Stewart.* INDEFATIGABLE ISL.: *Rorud;* Academy Bay, epiphyte on *Xanthoxylon* trees at 1100–2000 ft., *Svenson* no. 208. JAMES ISL.: *Stewart.*

PSILOTACEAE

PSILOTUM Sw.

P. NUDUM (L.) Griseb. Abh. Ges. Wiss. Goettingen **7:** 278 (1857). *P. triquetrum* Sw. in Schrad. Journ. Bot. **1800**[2]**:** 109 (1801); Riley, Kew Bull. **1925:** 231 (1925).—JAMES ISL.: *Riley.*

COCOS ISLAND

(Only the pteridophytes collected by the Astor Expedition are included in this list.)

FILICES

ASPLENIUM L.

A. MACRAEI Hook. & Grev. Ic. Fil. t.217 (1831).—Wafer Bay, abundant on cliff walls at 700 ft., *Svenson* no. 339.

This material is exactly like the type from Hawaii collected by Macrae (Kew) and the same as the collection at Kew of *A. dubium* (*Brackenridge* no. 55, consisting of rather poor specimens) from the Fiji Islands (?). The specimens previously collected on Cocos Island under the name *A. cristatum* (*Stewart* no. 228) and as *A. rhizophyllum* (*Snodgrass & Heller* no. 954) are *A. Macraei.*

DENNSTAEDTIA Bernh.

D. GLOBULIFERA (Poir.) Hieron, in Engler, Bot. Jahr. **34:** 455 (1904).—Wafer Bay, abundant from near sea level to above 1000 ft., *Svenson* no. 343.

DANAEA J. E. Smith

D. NODOSA (L.) Sm. Mém. Ac. Turin **5:** 420 t.9, fig. 11 (1793).—Wafer Bay, abundant in alluvial soil along brook, *Svenson* no. 328 (Pl. 10). I am of the opinion that the "small palms" in Stewart's illustration, pl. 33 (op. cit.) are this species.

DICRANOPTERIS Bernh.

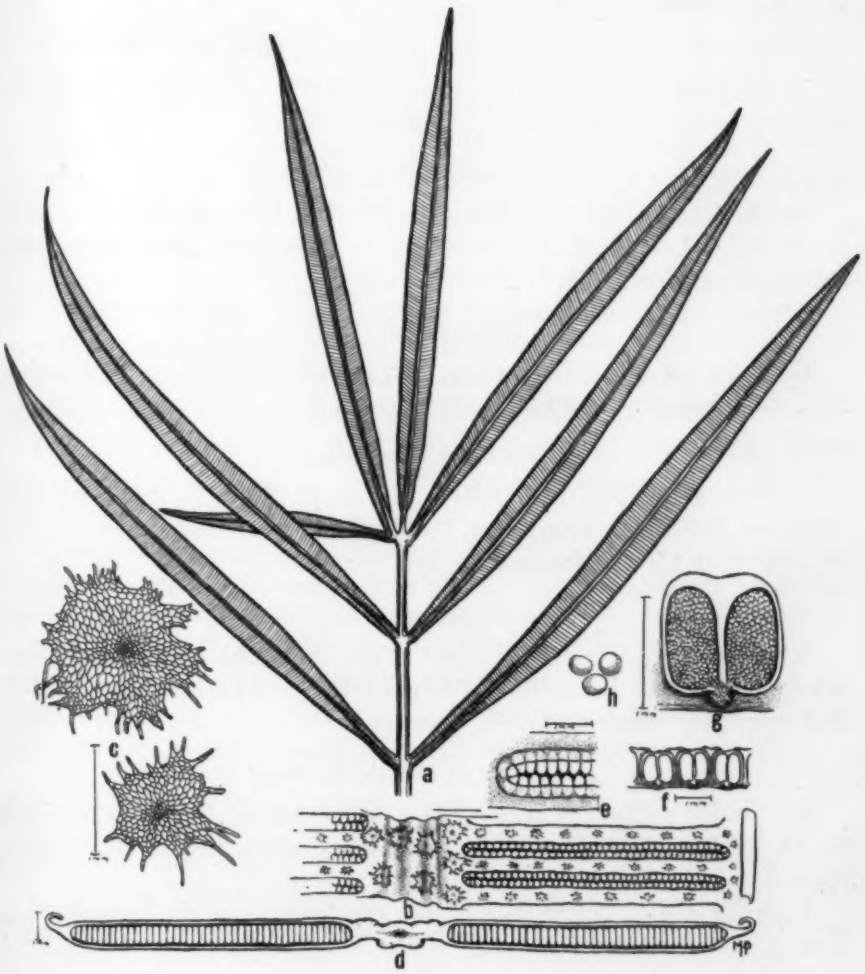
D. PECTINATA (Willd.) Underw. Bull. Torrey Club **34:** 260 (1907). *Mertensia pectinata* Willd. Sv. Vet. Akad. Handl. ser. 2, **25:** 168 (1804).—Wafer Bay, covering banks of stream at 150 ft., *Svenson* no. 332.

ELAPHOGLOSSUM Schott

E. APODUM (Klf.) Schott, Gen. Fil. ad t.14 (1834). *Acrostichum*

Explanation of Plate 10

Pl. 10. DANAEA NODOSA (no. 328): a, tip of frond ×½. b, portion of fertile pinna (lower surface) with enlarged scales (c) and as seen in cross section (d). e–h, details of sporangia and spores.



SVENSON: PTERIDOPHYTA

apodum Kaulf. Enum. 59 (1824).—Wafer Bay, epiphyte at 1000 ft., *Svenson* no. 403.

E. CRINITUM (L.) Christ, Mon. 112, fig. 53 (1899). *Acrostichum crinitum* L. Sp. Pl. 1068 (1753).—Wafer Bay, epiphyte on trunks of tree ferns, 1000 ft., *Svenson* no. 402.

HYMENOPHYLLUM J. E. Smith

H. POLYANTHOS Sw. in Schrad. Journ. **1800**[2]: 102 (1801).—Wafer Bay, on mossy tree trunks at 1000 ft., *Svenson* no. 345.

HYPOLEPIS Bernh.

H. aff. VISCOSA (Karst.) Mett. Ann. Sc. Nat. V. **2**: 238 (1864) (nomen); Karst. Fl. Col. **2**: 89, t.145, 146 (1869).—Wafer Bay, along brook up to 800 ft., *Svenson* no. 341.

LINDSAEA Dryand

L. MONTANA Fée, Mém. Foug, **11**: 17, t.6, fig. 2 (1866).—Chatham Bay, along brook near sea level, *Svenson* no. 433.

NEPHROLEPIS Schott

N. BISERRATA (Sw.) Schott, Gen. Fil. ad pl. 3 (1834). *Aspidium biserratum* Sw. in Schrad. Journ. Bot. **1800**[2]: 32 (1801).—Wafer Bay, banks of the stream at 150 ft., *Svenson* no. 350.

OLEANDRA Cav.

O. ARTICULATA (Sw.) Presl, Tent. Pter. 78 (1836). *Aspidium articulatum* Sw. in Schrad. Journ. Bot. **1800**[2]: 30 (1801).—Chatham Bay: an abundant epiphyte, *Svenson* no. 312.

POLYBOTRYA Humb. & Bonpl.

POLYBOTRYA CERVINA (L.) Klf. Enum. 55 (1824). *Osmunda cervina* L. Sp. Pl. 1065 (1753).—Wafer Bay, on ground along brook, 200–1000 ft., *Svenson* no. 342.

POLYBOTRYA SP. Wafer Bay, in rock crevices and on the ground 800 ft., *Svenson* no. 340 (young plants).

POLYPODIUM L.

P. ASTROLEPIS Liebm. Dansk. Vid. Selsk. Skrift. V. **1**: 185 (1849); Weatherby, Contrib. Gray Herb. no. 65: 6 (1922).—Wafer Bay, a common epiphyte along brook, *Svenson* no. 321.

P. LATUM (Moore) Sodiro, Crypt. Vasc. Quit. 371 (1893). *Camplyoneurum latum* Moore, Ind. Fil. 225 (1861).—Chatham Bay, abundant on hillsides and along streams, *Svenson* no. 311.

Saccoloma Kaulf.

S. elegans Kaulf. Berl. Jahrb. Pharm. **1820:** 51 (1820).—Wafer Bay, rather common on ground in shady places, 300 ft., *Svenson* no. 336.

Trichomanes L.

T. Cocos Christ, Bull. Boiss. II. **4:** 943 (1904).—Wafer Bay, abundant on trunks of tree ferns at app. 1000 ft., *Svenson* no. 349 (Pl. 8, fig. 2).

This endemic species, closely related to *T. capillaceum* L., is described as having the pinnae more sprawling so that the frond becomes flabellate at its periphery. The segments are said to be thicker and somewhat dilated at the ends, and the receptacles less open; the color of the plant, in general, is darker.

T. elegans Rich. Act. Soc. Hist. Nat. Paris **1:** 114 (1792).—Chatham Bay, dark moist places beneath ledges; fronds bluish-green. Common to 1000 ft., and probably above, *Svenson* no. 313, alt., 50 ft.

T. Galeottii Fourn. Bull. Soc. Fr. **15**. 144, 147 (1868).—Wafer Bay, epiphyte with translucent fronds, at 800 ft., *Svenson* no. 407.

T. Hookeri Presl., Abh. Boehm. Ges. Wiss. v. **3**. 108 (1843).—Wafer Bay, on a decayed stump at 800 ft. but not otherwise noted. *Svenson* no. 344.

T. radicans Sw. in Schrad. Jour. **1800:**[2] 97 (1801).—Chatham Bay, abundantly climbing on damp rocks and tree trunks, but only one clump seen in fruiting stage, 800 ft., *Svenson* no. 328.

Vittaria J. E. Smith

V. lineata (L.) Sm., Mém. Acad. Turin **5:** 413, pl. 9, fig. 5 (1793). Wafer Bay, epiphyte near sea level, *Svenson* no. 330.

Lycopodiaceae

Lycopodium L.

L. Pittieri Christ, Bull. Soc. Bot. Genève, ser. 2, **1:** 236 (1909). Wafer Bay, a fairly common epiphyte, the branches hanging vertically, *Svenson* no. 324. (det. W. R. Maxon).

Selaginellaceae

Selaginella Beauv.

S. horizontalis (Presl) Spring, Mon. Lycop. pt. 2, 264 (1848). Wafer Bay, beneath trees near beach, *Svenson* no. 320. (det. A. H. G. Alston).

Brooklyn Botanic Garden,
Brooklyn, New York

INDEX TO AMERICAN BOTANICAL LITERATURE
1935–1937

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

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